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Work-Related Musculoskeletal Disorders in Dental Professionals and Dental Hygiene Students

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Work-related Musculoskeletal Disorders
In
Dental Professionals and Dental Hygiene Students

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B.S., Providence College, 2000

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Work-related Musculoskeletal Disorders in Dental Professionals and Students

Presented by

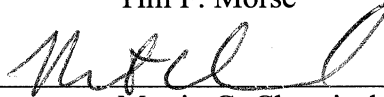
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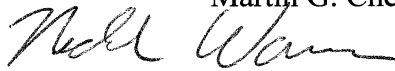
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Abstract

In 1985, in a report titled “Identification and Control of Work-Related Diseases”, the World Health Organization noted that work-related disease (WRD) is multifactorial in nature, and thus, may involve a number of physical, psychosocial, individual, organizational and sociocultural variables. A number of occupations have since (and had previously) been analyzed by researchers attempting to single out specific risk factors inherent in those positions that may contribute to WRD. Cumulative trauma disorders (MSDs) have especially been focused on, as such disorders account for a large portion of occupational disease claims. Among the occupations studied is dental hygiene, which has for more than a decade been linked to several risky exposures. The following paper is a summary of findings from a five-year study (funded by the National Institute for Occupational Safety and Health [NIOSH]) examining a group of Connecticut dental hygienists and a group of Connecticut dental hygiene students, two of five international cohorts involved in the study. For analysis purposes, the student cohort was broken down into those with training-related clinical exposures alone (dental hygiene students) and those who *had* worked or *currently* worked in the dental field as well as participating in training exposures (dental assistants). The thesis includes a discussion of the dental hygienists, dental assistants’ and dental hygiene students’ tasks including possible risk factors for work-related MSDs (based on evidence gathered from the 1997 NIOSH publication “Musculoskeletal Disorders and Workplace Factors”), a summary of study methods and a preliminary analysis of collected data. Two specific physical outcomes, neck pain and neck spasm, are also examined in further detail, leading to

recommendations for future research (as is being conducted by the author) and possible interventions.

Chapter 1. Introduction

Work-related Musculoskeletal Disorders

The term musculoskeletal disorder (MSD) describes a series of microtraumas of bones, joints, ligaments, muscles tendons, bursae, blood vessels and nerves that accumulate in the body and may develop into more serious injury (Szeluga, 2002). Patients with such disorders may exhibit any of the following outcomes: pain, paresthesia, stiffness, swelling, redness and/or weakness (Zakaria *et al*, 2002). MSDs can result from the body's inability to heal itself from the long-term effects of repetitive motions, forceful movements, awkward postures, and exposure to vibration and/or mechanical stress (Liskiewicz and Kerschbaum, 1997). The term MSD may also include such terms as RSI (repetitive strain injury), which are descriptive of the nature of the injury or risk factor, and/or CTDUE (cumulative trauma disorders of the upper extremity) and MSD (musculoskeletal disorder) that refer to specific body locations or body systems (Zakaria *et al*, 2002).

Musculoskeletal disorders may be occupational (work-related musculoskeletal disorders – WRMSDs) or non-occupational. Several researchers in the field of WRMSD note that work conditions may cause or exacerbate illness, however, other factors such as characteristics of the worker (age, gender) along with psychosocial issues (supervisor and coworker social support) must be considered as well (Armstrong *et al*, 1986). Along with the World Health Organization (WHO), NIOSH (National Institute for Occupational Safety and Health) also recognizes the multifactorial nature of WRMSDs, noting that such diseases could be partially caused by workplace conditions or exacerbated by

workplace exposures but are also influenced by organizational, psychosocial and sociocultural variables, among other issues.

Prevalence of WRMSDs

In General

Although MSD may seem like an umbrella term encompassing many variables, and thus difficult to categorize, the impact of such disorders is disturbingly clear in regard to both national and state surveillance and specific epidemiological studies. In terms of national surveillance, the Bureau of Labor and Statistics (BLS) publishes the only routinely collected, national source of information about occupational injuries and illnesses, the organization's Annual Survey of Occupational Injuries and Illnesses (ANSOII). Although fraught with limitations (to be discussed later in the text), the ANSOII can be a helpful instrument in assessing national prevalence of musculoskeletal illnesses compared to epidemiological studies that generally focus on specific risk factors or occupations. The annual BLS survey is a stratified random sample of 250,000 private-sector establishments, (making up about 2.8% of all workplaces nationally) excluding farms with fewer than 10 employees, government workers, self-employed and private households. The survey uses OSHA 300 logs (previously OSHA 200 logs), required by law to be completed by OSHA regulated businesses, to assess the yearly incidence of injuries and illnesses reported by individual employers.

According to the ANSOII, 362,500 total illness cases were reported in 2000 down from 372,300 in 1999. The approximate illness rate for full time employees was 39.4 per 10,000 workers. About half (45.5%) of all reported illnesses involved time away from

work (165,100 cases). Although BLS does not separate musculoskeletal disease from other disease outcomes, the survey does include a “repeated trauma” category encompassing all conditions associated with repeated motion, vibration and pressure (*i.e.* noise related hearing loss, Raynaud’s syndrome). The repeated trauma category is not specific to the musculoskeletal system; however, the majority of reported MSDs are contained in this category as most MSDs are considered the outcome of excessive repetition. In 2000, 241,800 cases of repeated trauma were reported, approximately 67% of all illnesses recorded. The rate of repeated trauma illness among full time employees was calculated as 26.3/10,000 workers (BLS, 2000).

The BLS annual survey also includes a category of recorded sprains, strains and tears under injury data. Although musculoskeletal disorders are generally considered illnesses rather than injuries, ANSOII relies on employer logs that may be misclassified based upon the employer’s definition of injury or illness occurrence. Because it is probable that some MSDs, especially neck and shoulder disorders, may be considered by the employer as strain injuries, it may be prudent to consider prevalence data for strains and sprains as well. In 2000, 728,202 sprains, strains and tears were recorded by BLS of a total of 5,287,600 nonfatal injuries reported (BLS, 2000).

The state of Connecticut also publishes a yearly occupational disease report of reportable occupational illnesses (Morse and Kenta-Bibi, 2002). The report includes BLS illness data for Connecticut, data from the Connecticut Worker’s Compensation Commission and Connecticut physician reports to ODSS (Occupational Disease Surveillance System). According to the most recent publication, 6,396 cases of occupational illness were reported to BLS from Connecticut workplaces in 2000. Of the

total illness cases, approximately 60% (3,827) were categorized as musculoskeletal disease (repetitive trauma). This represents a 16% increase from 1999 data (3,306 cases) and is calculated as a rate of 23.2 per 10,000 workers. In terms of workers' compensation data, 4147 illness cases were claimed, 2075 (50%) of which were related to musculoskeletal illness. Carpal tunnel syndrome was the most frequently reported diagnosis, making up approximately 27% of all musculoskeletal disease claims. Physician reports show a similar trend, with 56% of the total reported illnesses (2,095) being related to the musculoskeletal system (a total of 1,174 cases). Both workers' compensation and physician reports for musculoskeletal disorders also include sprains and strains that are considered cumulative in nature (except lower back reports).

Prevalence of Specific Neck WRMSDs:

Historically, researchers in the field of musculoskeletal disorders have focused on either all upper extremity disorders (CTDUE) or merely cumulative trauma disorders. Few studies focus on specific body locations when calculating ergonomic risk. However, data have suggested that more specific CTDUE such as those localized to the shoulder, elbow and neck may have different risk factors. Furthermore, different types of occupations even within the same occupational category (as dentists, dental hygienists, assistants all fall under the dental professional category) may be at risk for different types of CTDUE.

One of the specific objectives of this study was to attempt to find associations between subjective and objective symptoms and occupational risk factors. As discussed above, dental hygienist are exposed to a variety of biomechanical and vibration-related risks, as well as psychosocial and organizational factors. Anthropometric risks such as

age, height, weight and gender may also play a part in disease outcomes. As it is difficult to discuss in depth the impact of specific risk factors on the variety of disease outcomes surveyed here, an overview of descriptive and tabular data is presented first and further analysis is focused on three of the most common outcomes: subjective neck symptoms and physician diagnosed superior trapezius pain and trigger point. The prevalence of such disorders found both in this study and previous studies (both in the dental field and in other occupations) will be discussed, as well as an exploration of the etiology of certain types of neck disorders, possible risk factors correlating with such disorders, and recommendations for hygienists and students in controlling exposures that may put them at risk for neck disease.

Few studies have focused exclusively on MSDS originating in the neck, preferring to group these disorders with shoulder and sometimes all upper extremity cases (*i.e.* cervicobrachial disorder). Often, neck/shoulder disorders are separated into two groups: one involving problems confined to the shoulder joint area and the other involving problems confined to the upper shoulder and neck area. The first group, including such diagnoses as rotator cuff syndrome, has been well documented in the literature as being associated with dynamic work with heavy loads. Alternately, problems of the upper shoulder and neck are thought to be associated with repeated or sustained exertion in awkward or static postures, but often with low external loads (Hagberg and Wegman, 1987).

Those neck/shoulder MSDs confined to the second group are again separated into classes dependent on the clinical presentation of neck symptoms. The first class consists of the *cervical syndromes*. Cervical myalgia, cervical strain, and occupational cervico-

brachial disorder (OCD) are some examples of diagnoses that fall under this heading. Cervical syndromes are associated with pain radiating from the neck to the upper extremity, or pain in the neck and numbness in the hand with limited neck movement and pain on neck movement. In contrast, *tension neck syndrome* (TNS), which may include such diagnoses as trapezius myalgia, is generally characterized by a feeling of fatigue and stiffness in the neck, neck pain or headache radiating from the neck. Symptoms may also involved tender spots or palpable hardenings termed trigger points (Viikari-Juntura, 1983). Although the above case definitions apply to many neck studies, other researchers have used combined definitions for similar syndromes.

Although limitations in defining prevalence do exist, estimates of subjective and objective neck pain may aid in the comparison of different occupations with similar work tasks or risk factors. Subjective reports of neck pain in the female working population have been estimated at 61.1% (Barnekow-Bergkvist *et al*, 1998). The highest rates of neck pain exist in occupations with extensive repetitive activity of the hands, such as data entry workers, and those with prolonged static and awkward postures of the neck and arms, such as cashiers. The rate of subjective neck/shoulder pain in VDT operators and cashiers has been estimated at 51% (Demure *et al*, 2000) and 70% (Lundburg *et al*, 1999) respectively.

Objective neck symptoms are generally assessed by physician diagnosis and may be validated by electromyography (EMG). EMG tracings record the level of activity in a specific muscle, which may be an important indicator of the level of use, and thus, the level of possible disability. A comprehensive study done by Anderson *et al* examined both subjective neck pain and physician induced neck pressure or tenderness in a random

sample of 3123 workers at 19 plants (2002). Approximately 6.2% of workers exhibited signs of tension neck syndrome, defined as both neck pain and palpable tenderness. However, in a study done exclusively in scissor makers, 61% showed signs of tension neck using the same diagnostic criteria (Armstrong *et al*, 1986).

Limitations of prevalence data

Unfortunately for researchers attempting to quantify MSD prevalence, both national and state surveillance systems have serious limitations. National surveillance data, as compiled by BLS, and state surveillance data, from worker's compensation or physician reporting records, are limited by the quality of employer and physician reporting to the system. Reports of illness may be misclassified or miscoded in terms of exposures, presenting an inaccurate picture of risk. Often a physician may not assess an accurate picture of occupational risk, thereby preventing the disease from being categorized as occupational. The number of affected workers that report their illness also limits surveillance; those that are more severely ill may leave work before reporting, evading capture by surveillance data and misrepresenting the current prevalence of disease as only the healthy workers are left to be surveyed (the healthy worker effect). Workers may choose to use private insurance or pay out of pocket rather than utilize workers' compensation benefits. State surveillance through WCC or ODSS also varies in policy by region and over time, making intrastate and interstate comparisons difficult. Different states may have different compliance rates for each reporting system. In terms of national surveillance, the Bureau of Labor and Statistics ANSOII survey is the most frequently used, as it is both nationwide and annually collected. However, ANSOII is a

survey rather than a census, and thus, includes only 2.8% of all American workplaces, excluding small farms, those privately or self-employed and government employees (who have been found by state surveillance to be at increased risk for MSDs) (Morse and Kenta-Bibi, 2002). Employers may be reluctant to accurately report injuries and illnesses to OSHA, fearing that such reports may result in inspections and fines. Lastly, exposure categories differ among systems, and definitive criteria and case definitions for classification of symptoms is controversial. For example, the term “repeated trauma” in ANSOII includes most MSD-related claims but also noise related hearing loss, which is not considered musculoskeletal in nature but may be caused by excessive, repeated noise.

Cost of WRMSDs

The cost of an injury or illness, such as a musculoskeletal disorder is somewhat difficult to calculate. Cost is generally calculated from workers’ compensation claims. However, this method ignores the many victims who either do not file or instead pay out-of-pocket (a cost estimated at \$71 million per year in Connecticut alone)(Morse, 1998) or through a private insurance plan. A population- based study done of nearly 14,000 employees in CT found that only 5% of those reporting musculoskeletal pain filed for workers’ compensation benefits (Morse, 1998). Workers were more likely to claim if: a doctor had diagnosed MSD, surgical intervention was involved, the worker was a union member, and if the worker was paid hourly versus salaried. In a follow-up capture-recapture analysis, the authors found that over 13,000 MSD cases were not captured either by worker’s compensation or physician reporting (Morse, 2001).

Thus, because it is nearly impossible to estimate the costs of unclaimed or unreported cases, statistics generally focus only on valid worker's compensation claims. When calculating the total cost of musculoskeletal disorders, both direct and indirect costs must be considered. Direct costs, such as the cost of medical bills and wage reimbursement, have been estimated at \$563 million annually in the U.S for upper extremity MSDs alone (this figure does not include low back, one of the costliest MSDs)(Webster and Snook, 1994). Upper extremity MSD cases in the U.S. average \$8,070 per claim with a median of \$824 per claim (with the large difference between mean and median indicating that several claims are very costly). For upper and lower extremity MSDs (including lower back), the National Academy of Social Insurance calculated direct workers' compensation costs at \$55.2 billion in 1996 (Mont *et al*, 1999), while other studies place the estimate from \$13 to \$20 billion annually (NIOSH, 1996; AFL-CIO, 1997). Work-related upper-extremity musculoskeletal disorders account for more than 5% of all workers' compensation claims (Brogmus *et al*, 1996). In the state of Connecticut alone, the estimated total direct cost for MSDs has been calculated at \$25 million: with a mean of \$14,729 and a median of \$5213 per claim (Webster and Snook, 1994).

Although disturbing enough, the above estimates fail to account for the largest portion of the expense of MSDs: indirect costs. Workers' compensation does not reimburse the claimant the full cost of lost time (only a percentage), nor does the system compensate the company for lost production due to absenteeism or restricted duty, the cost of recruiting and training new employees to replace those injured, degradations in quality, increased scrap and rework or decreased customer satisfaction and loyalty.

Estimates have placed indirect costs about 3-5 times that of direct costs: thus indirect costs for the U.S would be \$150-250 billion, while CT residents would assume costs of \$90-150 million (Mont *et al*, 1999).

Chapter 2. Risk factors involved in the development of WRMSDs

In 1997, NIOSH published a comprehensive review of the current epidemiological evidence available on musculoskeletal disorders and occupational exposures. The report, titled “Musculoskeletal Disorders and Workplace Factors”, reviewed over 600 studies that had linked certain risk factors to musculoskeletal outcomes. Basing their judgments on the quality (control of bias and confounders, use of specific diagnostic criteria) and quantity of studies available, the authors placed specific risk factors in four different categories: *strong evidence* of work-relatedness, *evidence* of work-relatedness, *insufficient evidence* of work-relatedness and *evidence of no effect* of work factors. Several risk factors were evaluated for each body region, (neck, shoulder, elbow, hand/wrist and back) including repetition, force, posture, vibration and combinations of these factors.

Repetition:

According to national surveillance, MSDs are most often attributed to repetitive motion especially in the hand or wrist. Repetition has been causally linked to increased incidences in both hand/wrist disorders and neck/ shoulder disorders; NIOSH cites *evidence* of work-relatedness stating that “convincing epidemiological evidence shows a causal relationship” between repetition and MSD outcomes in these locations (NIOSH, 1997). In neck and shoulder disorders, both the number and frequency of neck movements or hand/wrist movements may define repetition. Of 26 studies examining neck and shoulder MSDs, 20 showed a statistically significant positive correlation

between repetition and neck or neck/shoulder MSDs; 11 studies reported an odds ratio greater than 3.0. The causal relationship between hand/wrist disorders and repetition is also convincing. In this case, NIOSH has defined repetition as involving repeated hand/finger or wrist movements “such as hand gripping or wrist extension/flexion, ulnar/radial deviation, and supination or pronation” (NIOSH, 1997). The strength of the association between carpal tunnel syndrome and repetition ranges from an OR of 2 to 15; for hand/wrist tendonitis and repetition, relative risks range from 1.4 to 6.2.

Theories of the mechanism underlying repetitive MSDs suggest similar models for both hand and wrist and neck injury. High levels of repetitive movement can cause tendons to stretch and compress, leading to ischemia and microtears. Over time, inflammation may compress the nerves encapsulated in tendon sheaths. Beckenbaugh *et al* suggest that synovial tissue irritation and inflammation results from a high level of repetitive movement, subsequently placing pressure on the median nerve in the carpal tunnel sheath (1995). Demonstration of median nerve dysfunction is the primary objective indicator of carpal tunnel syndrome. Repetitive motion in the neck may also cause nerve compression, indicative of cervical disorders, but more often leads to muscle inflammation and possibly fibrous nodule formations called trigger points (Hagberg and Wegman, 1987).

Force:

Forceful grips and movements have also been implicated as risk factors in the development of MSDs (Strong and Lennetz, 1992). NIOSH defines force as an external

load or internal force on a body structure. Force can be expressed as a unit of magnitude (in newtons or pounds) or as a percentage of a subject's strength as measured by electromyography. Studies have shown that dynamic, frequent contractions above 10-20% of the subject's maximum voluntary contraction (MVC) can be considered forceful especially if frequent rest breaks are not allowed (Larsson *et al*, 1990). High force work also increases the stress on muscles and tendon sheaths, leading to reduced blood flow and possible impingement of nerves. Researchers have theorized that the lack of oxygen supply to the muscles also causes a build up of anaerobic respiratory waste products (*i.e.* lactic acid) eventually leading to fatigue, and increasing the possibility for injury especially with cumulative exposure (Polynai *et al*, 1997). Studies have reported an increased risk of median nerve entrapment, and subsequently CTS, from a forceful grip, with higher risks for gripping small diameter objects and for an increased degree of precision (Liss *et al*, 1995). NIOSH implicates force as a risk factor in neck, elbow, hand/wrist and lower back MSDs stating *evidence* of work-relatedness (and in the case of low back MSDs-strong evidence).

Posture:

Awkward postures and prolonged static postures have also been causally linked to musculoskeletal disorders by several studies. Awkward postures are generally defined by deviation from neutral posture and may involve varying degrees of ulnar and radial deviation, supination, pronation, flexion, extension and abduction. Hand and wrist extension away from neutral posture has also been associated with compression of the median nerve through inflammation of the synovial sheath (Tanaka *et al*, 1994).

Laboratory studies confirm these studies, showing that pressure in the carpal tunnel is increased during wrist extension and flexion (Gelberman *et al*, 1981). Ulnar and radial deviation may also place stress on the epicondyle tendon of the elbow, resulting in epicondylitis, a condition categorized by microtears in the tendon tissue (also known as “golf” or “tennis” elbow). (NIOSH, 1997).

The strongest evidence of a link between posture and MSDs is found in the literature on neck disorders. NIOSH has found *strong evidence* of causality; of 31 studies, 27 found statistically significant positive correlations between awkward or static posture and neck MSDs with odds ratios ranging from 1.6-7.0. A dose response relationship with number of hours of VDT use was also noted.

Tasks involving awkward and static postures generate continuous muscle activity (even static contraction is dynamic!). One well-accepted theory proposes that only those muscle fibers sensitive to nerve stimulation are recruited for low level activity for prolonged periods. These muscles, called Cinderella fibers, do not share this load on a rotating basis and continue to be active when a stronger force is required. Intramuscular pressure can rise during continued muscle contraction to such a level that it blocks the flow of blood, and thus, oxygen to working muscles. Aerobic respiration eventually ceases replaced by anaerobic mechanisms. Muscle fibers fatigue and develop microtears (cumulative trauma) due to the accumulation of waste products such as lactic acid from anaerobic respiration (Fredriksson, 1999). Researchers hypothesize that disturbance of muscular microcirculation can lead to the sensitization of pain receptors in the muscle and pain at rest, so low threshold can activate stimuli or even spontaneous activity (a possible explanation for trigger points) (Armstrong *et al*, 1986). Muscles, such as the

supraspinatus, in fascial compartments may be especially prone to this mechanism. A study done with dental hygienists conducted by Oberg *et al*, found increased trapezius muscle activity by EMG with sustained static postures (1995). Fredriksson *et al* noted that the inability to relax the neck even if the muscles are doing no work is predictive of trapezius myalgia (1999).

Vibration:

As of the publication of NIOSH's summary in 1997, few studies had been done examining the role of vibration in MSDs. NIOSH cites *insufficient evidence* for a link between neck, shoulder and elbow MSDs and vibration. However, there is *evidence* for a link between CTS and vibration and *strong evidence* of causality between whole-body vibration (WBV) and lower back disorders and between segmental vibration and hand-arm vibration syndrome.

The term WBV refers to the low frequency oscillations transferred to the entire body (as opposed to segmental vibration, which is absorbed by specific regions, generally the upper extremities). Whole body vibration is typically transmitted through a seat or platform in a vehicle, putting such workers as truck drivers at risk for lower back disorders. Of the 19 NIOSH- reviewed studies examining WBV and lower back pain, 15 demonstrated positive associations with risk estimates ranging from 1.2 to 39.5 (dependant on use of subjective versus objective assessment methods). These results combined with consistent laboratory studies led NIOSH to cite *strong evidence* for causality between WBV and lower back disorders.

NIOSH also cites *evidence* of the role of segmental vibration in carpal tunnel syndrome. Vibration may also impair nerve velocity by thickening synovial sheath around the carpal tunnel, resulting in compression of the median nerve (a similar mechanism has been theorized for the ulnar and spinal nerves) (Cherniack *et al*, 1994). Furthermore, the transmission of vibration may also impair tactile sensitivity as the fingertips absorb much of the energy involved. Of the nine studies examined, eight used either a physical examination and/or a nerve conduction study to determine the case definition of CTS, however, only three studies blinded the investigator to case and/or exposure status. Of these three studies, two found $OR > 10$ between vibratory tasks and development of CTS.

HAV (hand-arm vibration) is defined by NIOSH as “the transfer of vibration from a tool to a workers’ hand and arm (NIOSH, 1997). The acceleration level of the tool used characterizes the level of vibration transferred. HAVS (hand-arm vibration syndrome) is a term used to describe the health effects linked to HAV including: tingling and blanching of the fingers, pain in response to cold and decreased grip strength and finger dexterity. It is theorized that segmental vibration interferes with vasoconstriction of capillaries in the digits, leading to restricted blood flow and eventually to complete vasospasm, as evidenced by the presence of “white fingers” in secondary Raynaud’s. The 1997 NIOSH compilation discussed only those HAVS studies published after 1989 as a 1989 NIOSH publication examined HAVS studies prior to this time. Of the 20 studies cited, NIOSH recognized “substantial evidence” that as intensity and duration to vibrating tools increases, the risk of HAVS increases. Although the majority of studies did not report odds ratios, four studies found $OR > 10$.

Psychosocial Factors:

Unlike physical factors associated with MSDs, psychosocial factors generally encompass a number of variables involving the work environment, the non-occupational environment and individual factors. Some researchers have chosen to separate certain psychosocial factors into one of these three areas, however, since this section of the thesis focuses on NIOSH's 1997 report, and NIOSH classifies psychosocial disorders according to all three criteria, this classification will be used. Several theories exist as to the anatomical mechanism of the involvement of psychosocial factors in the development of MSDs. In general, psychosocial demands are thought to either: exacerbate a task-related strain, increase reporting of injury caused by a physical agent, or contribute to the chronicity of an acute task-related injury (Bergqvist *et al*, 1984; Ursin *et al*, 1988). In regards to upper extremity MSDs, the data reviewed by NIOSH support a positive association between MSDs and psychosocial factors such as work intensity and monotony and a negative association with social support. NIOSH notes that psychosocial demands seem to correlate more strongly with neck/shoulder MSDs (although this may be due to the fact that more neck studies include psychosocial variables in their analysis). In regards to back disorders, work intensity and job dissatisfaction correlate positively with MSDs in several studies, while some evidence exists for an association between low job control and back disorders.

The evidence to date suggests that although psychosocial factors may be influenced by physical demands, their association with MSDs may also be independent of

these factors. More precise objective methods are needed in order to more fully assess the impact of psychosocial factors on the worker.

Chapter 3. Dental professionals and students

Job analysis

The American Dental Hygiene Association defines a dental hygienist as a “licensed oral health professional who focuses on preventing and treating oral disease- both to protect teeth and gums, and also to protect patients’ total health”(ADHA, 2002). The specific makeup of a hygienist’s duties varies by state, with each state adopting a Dental Practice Act, defining that state’s specific range of services that may be performed. In general, a dental hygienist may do any of the following:

- Root planing (the smoothing via instrumentation of a tooth’s roots through removal of fine residual calculus and or disease cementation)
- Scaling (removal of deposits such as calculus, plaque and stains via instrumentation from the tooth surface; it includes supragingival and subgingival [both above and below the gumline] using manual and ultrasonic techniques)
- Polishing (removal via instrumentation of stains and non-mineralized deposits from the teeth surface)
- Exposing, processing and evaluating radiographs
- Performing oral health assessments (examining patients’ teeth and gums for the presence of disease or abnormalities)
- Applying cavity preventing agents such as fluoride and pit and fissure sealants

- Counseling patients on oral hygiene techniques (*i.e.* how to floss, select a toothbrush) and good nutrition

Each state also has specific duties that the licensed dental hygienist may not perform. In some states, hygienists can do such tasks as:

- ❖ Administering local anesthesia
- ❖ Placing and carving fillings, filling materials and periodontal dressings
- ❖ Removing sutures
- ❖ Smoothing and polishing metal restorations

In Connecticut, the CT State Board of Dental Examiners defines the practice of dental hygiene as “the performance of educational, preventive and therapeutic services including: complete prophylaxis; the removal of calcareous deposits, accretions and stains from the supragingival and subgingival surfaces of the teeth by scaling, root planing and polishing; the application of pit and fissure sealants and topical solutions to exposed portions of the teeth; dental hygiene examinations and the charting of oral conditions; dental hygiene assessment, treatment planning and evaluation; and collaboration in the implementation of the oral health care regimen” (CTDPH Chapter 379a -Sec. 20-126l). Connecticut state law also defines those actions **not** to be performed by a licensed dental hygienist in the state including:

- (1) Diagnosis for dental procedures or dental treatment;

- (2) The cutting or removal of any hard or soft tissue or suturing;
- (3) The prescribing of drugs or medication which require the written or oral order of a licensed dentist or physician;
- (4) The administration of local, parenteral, inhalation or general anesthetic agents in connection with any dental operative procedure;
- (5) The taking of any impression of the teeth or jaws or the relationship of the teeth or jaws for the purpose of fabricating any appliance or prosthesis;
- (6) The placing, finishing and adjustment of temporary or final restorations, capping materials and cement bases.

In a 1994 survey by the American Dental Association (ADA), a sample of 135 dental hygienists reported that the top three activities that took the majority of their appointment time were: hand scaling or root planing (31.3%), ultrasonic scaling (18.5%), and polishing (10.5%) (Murphy, 1998).

Dental assistants are also an important part of the dental health care team. Assistants are generally not licensed in the state (are hygienists must be) and may perform any of three types of work: chairside, expanded function or circulating work. As the name implies, chairside dental assistants spend the majority of their time assisting the dentist or hygienist in patient treatment. Tasks of the chairside assistant may include passing instruments or other materials to dentists or hygienists and using suction devices to keep the patient's mouth clean and dry. Assistants may also sterilize instruments and equipment, prepare tray setups for dental procedures, and educate patients on good oral

health. Expanded function assistants generally have received additional training in dental care and may perform procedures under the direct or indirect supervision of the dentist. Such procedures may include making impressions and restorations, exposing radiographs and processing X-rays. Some expanded function assistants have similar duties as hygienists in that they may remove sutures and excess cement used in fillings and apply anesthetics and cavity preventive agents to gums and teeth (depending on state restrictions). Circulating dental assistants perform a variety of duties such as assisting the dental team members or taking part in sterilization techniques. Assistants may also have laboratory roles such as making casts or temporary crowns and office roles such as patient scheduling (Gaylor, 2000).

Dental students may be classified as either dental hygiene students or dental assistant students (as both types of schools exist). For the purposes of this study, only dental hygiene students' tasks will be examined (as all participants were from dental hygiene programs). As the student is preparing for the field of dental hygiene, he or she must simulate the procedures that will be encountered at work. Thus, accredited hygiene schools are required to provide at least 585 hours of supervised clinical time to each student (ADA, 2002). Schools vary as to the percentage of time spent learning specific tasks and individual student needs may steer the focus of the clinical time on problem areas. Because no study as yet has examined the proportion of clinical time students spend in each task, job analysis for dental hygiene students is a difficult task.

Dental hygienists, assistants and students use a variety of tools over the course of their workday. The type of instruments used and their use patterns may influence the

development of musculoskeletal disorders (Atwood and Michalak, 1992). Dental professionals may use either hand or powered instruments to remove calculus and reveal tissue loss. Hand scalers are generally used to remove low to medium level of plaque, as sufficient force is available to scale such calculus. Ultrasonic, or vibrating, scalers are primarily used on more difficult patients, those with heavy calculus covering much of the tooth surface. Ultrasonic scalers are generally heavier than their manual counterparts, as they require a cord attachment to a power source. Such devices operate at frequencies of 50-60 Hz (Atwood and Michalak, 1992). Slow speed handpieces, such as rubber cup polishers, are vibrating pieces that assist the dental care worker with polishing the tooth surface. Suction devices allow the removal of scaled calculus and saliva from the mouth and the hygienist or assistant may hold either a suction device or a hand mirror in the non-dominant hand while manually scaling. As the hygienists require a mirror for effective mouth visualization, he or she may ask the patient to handle the suction device, freeing the non-dominant hand for the mirror. Higher suction is needed for ultrasonic work, so the worker may be more likely to hold a suction device, versus manual scaling, a procedure where the patient may hold the suction device. Dental professionals also use x-ray machines to take dental pictures, syringes to administer anesthesia and hand mirrors to allow better visualization of the work area (the patient's mouth) (Murphy, 1998).

Prevalence of WRMSDs in dentistry

In addition to providing injury and illness statistics for workplaces surveyed by ANSOII, BLS also provides occupation specific data that may be useful in identifying occupations at high risk for certain disorders. Members of the dental care team are

included in OSHA SIC code 8021 (which includes dentists, dental hygienists and dental assistants). According to BLS, in 2000, dental offices reported approximately 903 cases of injury or illness (BLS, 2000). Because the available data regarding national prevalence of MSDs for specific occupations has some limitations (as discussed in the previous section), point prevalence estimates may also be made from individual studies (Akesson, 1999; MacDonald, 1988).

Dentists:

Research on cumulative trauma disorders in dental care has primarily focused on dentists, rather than the extended dental care team. In most dental settings, dentists are the primary decision makers on policy and scheduling, and thus, have the most influence over the inclusion of ergonomics into the practice. Although this specific study did not examine dentists, a review of prevalence data in this group may be beneficial to an understanding of MSD-related complaints in hygienists, assistants and students due to similarities in tasks and postures.

Reports of general musculoskeletal or neurological symptoms in dentists have been as high as 82% in one study (Marshall *et al*, 1997), with most studies recording around a 60% prevalence of MSD pain (Shugars, 1984). The most common locations of MSD pain were lower back, shoulder and neck (Moen, 1996). Furthermore, approximately 29% of dentists report some symptoms of peripheral neuropathy, with 17% having numbness and 15% reporting tingling in the hand/wrist area (Stockstill *et al*, 1993). Dentists are also at risk for a number of specific MSD-related diagnoses. Hagberg and Wegman noted that dentists have increased odds ratios for cervical

spondylosis and shoulder joint osteoarthritis as compared to the general population (1987).

Dental hygienists:

Prevalence data on dental hygienists is somewhat more difficult to find, as only recently have studies begun examining dental hygienists and dental assistants along with dentists. The prevalence of general MSD pain in hygienists ranges from 63% (Osborn 1990) to 96% (Szeluga, 2002; Sanders and Turcotte, 1997) depending on the specific population being studied. As with dentists, the most common sites of pain were the lower back, neck and shoulder, however, dental hygienists also frequently report hand/wrist pain, numbness and tingling (Osborn, 1990; MacDonald, 1988; Sanders and Turcotte, 1997). Approximately 60% of hygienists report symptoms of upper extremity neuropathy according to one survey of 260 practicing hygienists (Stentz, 1994). Studies using questionnaire alone to assess subjective neck pain have found prevalence rates as high as 82% in dental hygienists (Szeluga, 2002).

As for specific diagnoses, few studies have focused on MSDs beyond CTS; the prevalence of CTS in hygienists is generally in the range of 3-12% (based on objective testing) depending on the study cited and the criteria used in the case definition (Osborn, 1990; MacDonald, 1988; Werner, 2002; Conrad, 1993). Prevalence of CTS based on symptom reports of hand problems alone has been cited as high as 75% (Lalumandier *et al*, 2001). In comparison, the average prevalence of self-reported hand pain in the U.S. working population is approximately 21.6% (Tanaka *et al*, 1994). In a review of 1997 BLS data, Leigh and Miller found that dental hygiene ranked 1st among

all occupations for the number of reports of CTS per 1,000 employees. In comparison to dental assistants, hygienists have been shown to have a 3.7 times greater risk of CTS and odds ratios of 1.8-2.2 for hand/wrist, shoulder and neck symptoms (Liss *et al* 1995).

Werner *et al* estimated the prevalence of upper extremity tendonitis in hygienists at approximately 26% (2002). One study reported that 20.7% of dental hygienists examined showed signs of tension neck syndrome, 3 of 29 had left work due to the condition (Akesson, 1999).

Dental assistants:

In comparison to prevalence data on dentists and dental hygienists, the literature regarding dental assistants is sparse. Occupational health data in both dental assistants and students tends to focus on pathogen exposure rather than cumulative trauma. A prospective cohort study conducted by Akesson *et al* in female dental personnel found that 65% of dental assistants reported overall MSD pain, 35% of those fit the clinical criteria for specific MSD diagnoses (see study for case definitions)(1999). The same study reported a TNS prevalence of 21.4% in dental assistants (Akesson, 1999).

Lalumandier *et al* reported that 35% of dental assistants surveyed reported symptoms of CTS, 1.5 times higher than the general population (2001).

Dental hygiene students:

Perhaps because students are not considered in the realm of “occupational” health, few studies have attempted to estimate the prevalence of musculoskeletal complaints in

dental hygiene students. Indeed, one may argue that the term work-related musculoskeletal disorder is not applicable to training-related exposures. However, in the context that dental hygiene students will perform each task required of a hygienist at some point in their clinical training, comparisons are likely valid. Barry *et al* noted an increase in musculoskeletal pain and a movement away from neutral posture over the course of hygiene education, extending into the first two practicing years (1992). However, the study was limited to nine students, so the study may not be generalizable. In a 3-year study following dental hygiene students through their clinical education and the start of their career, Conrad *et al* found no change in median nerve velocity but a shift in vibrotactile thresholds characteristic of injury to fingertip nerve receptors (1993). As of yet, no large- scale survey has been done in this group, highlighting the need for relevant information in this area. A recent pilot study submitted by the authors examining the work tasks and the prevalence of MSDs in this cohort will be helpful in elucidating the risks to this group.

Risk factors for WRMSDs in the dental professions

As dental hygienists, assistants and hygiene students use similar tools and perform similar tasks, an analysis of risk factors associated with these tasks is applicable to each group. The risk factors discussed here are discussed in relation to hygienists, allowing that assistants and especially students perform the majority of these tasks as well. However, researchers should note that although tasks and tools may be similar, each dental professional spends varying amounts of time with each tool and task, both within their cohort and within individual workplaces.

A number of risk factors for MSDs are involved in prophylaxis (scaling, root planing, flossing and polishing), and as prophylaxis is a large portion of the hygienist's day, it is important to note which risk factors cited in NIOSH's 1997 publication may be applicable to these specific tasks. Table 1 also summarizes the physical risk factors inherent in specific prophylactic tasks.

Table 1: Physical risk factors for MSDs involved in prophylaxis

	Manual scaling	Ultrasonic scaling	Flossing	Polishing
<i>Repetition</i>	>30 hand/wrist movements/minute	?	>30 hand/wrist movements/minute	>30 hand/wrist movements/minute
<i>Force</i>	-pinch grip -compression of instrument	-pinch grip -compression of instrument	-pinch grip -compression of floss	-pinch grip -compression of handpiece
<i>Awkward postures</i>	-wrist ext and flex -neck flex -thumb ext -forearm rotation -arms abd -torso twist	-wrist ext and flex -neck flex -forearm rotation -arms abd -torso twist	-wrist ext and flex -neck flex -thumb ext -forearm rotation -arms abd -torso twist	-wrist ext and flex -neck flex -thumb ext -forearm rotation -arms abd -torso twist
<i>Static postures</i>	-arms abd -ulnar and radial deviation -neck flex -back flexion	-arms abd -ulnar and radial deviation -neck flex -back flexion	-arms abd -ulnar and radial deviation -neck flex -back flexion	-arms abd -ulnar and radial deviation -neck flex -back flexion
<i>Vibration</i>		high frequency		high frequency

Abbreviations: ext: extension; abd: abduction; flex: flexion

Repetition:

The task of scaling involves a high level of repetitive activity of the hand/wrist area. In order to remove heavy calculus from a patient's teeth, the hygienist will repeatedly scrape one small area of the tooth, often for several minutes at a time without rest. One study estimated that manual scaling, polishing and flossing involve greater than 30 hand/wrist movements per minute, a level which has been shown to lead to muscle

and tendon disorders (Bramson, 1998). Several researchers have implied that the increased incidence of CTS in hygienists may be attributable to this risk factor (Liss, 1995; Werner, 2002). Repetition has also been causally linked to increased incidences of neck and shoulder disorders (NIOSH, 1997); however no specific studies in dental hygienists have been found to support this (Murphy, 1998).

Force/Precision:

In addition to repetition, scaling (especially manual scaling) involves high levels of force and precision in order to remove hard calculus from the relatively small area of the tooth's surface. The maintenance of precision requires prolonged contraction of muscle groups, effectively disrupting the blood supply to these tissues. Without frequent breaks, fatigue may set in rapidly. Several studies in dental hygiene have implicated a high level of precision as a risk factor in MSDs including CTS (compression of median nerve by prolonged contraction of surrounding musculature and increased pressure on tendon sheath)(Abbas, 2001, Liss, 1995) and neck pain and spasm (high precision work requiring dexterity significantly increased trapezius muscle activity recorded by electromyography). (Milread and Erikson, 1994, Oberg, 1995).

Use of excess pinch force has been suggested as the greatest contributor to MSDs in dental hygienists (Strong and Lennartz, 1992). Research has shown that the hand is four times stronger in a power grip position than in the pinch grip position commonly used by dental professionals (Liskiewicz 1997) Electromyography data shows that hygienists used the most force in the task of flossing, approximately 20-22% of the maximum voluntary contraction (MVC) (Bramson 1998). In addition to the forceful

movements necessary for a strong pinch grip, compression forces of the instruments on the hand may increase the risk of acquiring MSDs. Furthermore, a stronger grip on a vibrating instrument may allow a greater percentage of vibration to be transmitted to the upper extremity, resulting in a greater risk of injury (Catovic *et al*, 1989).

Awkward and static postures:

In order to effectively access the patient's teeth, the hygienist must often maneuver his/her body into awkward positions. Hand and wrist extension is common, as well as ulnar and radial deviation, neck extension, flexion and rotation. Work away from neutral posture requires more force from muscles and tendons to accomplish the same task (Sanders and Turcotte, 1997). Habitual repetition of less effective work postures can cause soft tissues of muscles, ligaments and joint capsules to stretch and adapt to such compromised positions (Liskiewicz, 1997). In terms of awkward postures of the neck, Finsen *et al* found neck flexion exceeded 30 degrees 82% of the time in dentists (1998) and Akesson *et al* found neck flexion in dental hygienists exceeded 39 degrees 50% of the time (1997). Neck flexion of greater than 30 degrees has been implicated in several neck disorders, such as tension neck syndrome (Akesson, 1997). Further research with EMG elicited higher neck muscle activity, more subjective discomfort and greater head/neck flexion with the direct view (that is traditionally used) than either video camera/monitor or prism glasses. A study in dentists also correlated raising of the dominant and nondominant elbow and twisting the torso with neck pain (Rucker and Sunell, 2002).

High degrees of neck flexion are also combined with static neck and shoulder postures. The hygienist may focus on one area of the mouth for some time, turning only to reach the instrument tray. Dental work also often involves prolonged, unsupported extension of the hygienist's arm. Such static loading of neck/shoulder and arms may cause fatigue and subsequent neck pain, and has been implicated in chronic myalgia of the trapezius muscle, or tension neck syndrome in hygienists (Murphy, 1998) (Akesson, 1997). Few studies have been done on the length of time dental personnel spend in static postures and further research is needed in this area.

Dental personnel, especially hygienists and assistants, also spend the majority of their work time in a sitting position. Sitting work for more than 95% of day has been identified as risk factor for neck, upper back and lower back pain (Fredriksson, 2002). Positioning of the legs below the patient's chair has also been correlated to back pain in this population (Rucker and Sunell, 2002).

Vibration:

Another task in which dental hygienists are heavily involved in the use of ultrasonics, or vibrating handpieces. Although ultrasonics generally range from 50-60 Hz, dental drills may have frequencies as high as 10,000 Hz (Murphy, 1998). Recently, a role of vibration of high frequency dental instruments has been suggested in the onset of several MSDs including secondary Raynaud's phenomenon (cold induced vasospasm or blanching of the digits) and CTS (Hjortsberg *et al*, 1989). Pathologic damage to mechanoreceptors, thermoreceptors and nociceptors has been noted as early as the first clinical year (Conrad *et al*, 1993; Hjortsberg *et al*, 1989). Some researchers have theorized

that the use of tight-fitting gloves may also attenuate high frequency transmission (Deltombe, 2001).

Psychosocial/Organizational/Individual:

Along with physical risk factors, there are also a variety of job specific psychosocial and organizational risk factors commonly present in dental hygiene. The job is one of moderate control over work pace (e.g. the number of patients scheduled, the number of breaks allowed) as it is ultimately the dentists of the practice who make the majority of organizational decisions. Financial pressure to make a profit in the world of organized health care may lead dentists to overschedule their hygienists, resulting in overtime hours or fast pace. Hales and Bernard report that time pressure may overwhelm an individual's coping mechanisms and elicit a stress response, which may lead to increased muscle tension (1996). Hygienists often frequently work part time at several offices (BLS) that may have varied patient loads, amounts of break time, and degrees of patient difficulty (*i.e.* children versus an adult with heavy calculus). Akesson *et al* have shown that hygienists have very limited possibilities for changing work situations within their profession, and since their education is time consuming and often expensive, the decision to quit due to injury or illness may be difficult (1999). The hygienist must also deal with the stress of a worried and sometimes pained patient, which may lead to increased anxiety (for both!) (Sanders and Turcotte, 1997). Although no specific studies have examined stress related to patient anxiety in hygienists, studies have shown that client-centered practices tend to be more stressful occupations (Frost and Stricoff, 1997)

As with other occupations, dental hygienists may also have individual risk factors for MSDs. Age has been positively associated with subjective and objective symptoms in this occupational group (although this evidence does not exist in assistant or students), and women are more likely to report pain and be diagnosed with MSDs (Akesson, 1997; Frederiksson, 1999; Koeleva, 2003). However, researchers have theorized that gender differences may result in large part from formal or informal job segregation, different task distributions, and/or perceptions of gender discrimination that contribute to psychosocial strain (Punnett and Herbert, 1999). Furthermore, such gender-dependent medical conditions as pregnancy increase the risk for CTS (possibly due to the localized swelling involved with these conditions) (Frederiksson, 1999). Vibration-related disorders such as primary Raynauds' have been found to be more common in women (USDHHS, 1993), and thus, the use of ultrasonics may carry increased risk for this group.

Women also have a disadvantage anthropometrically. On average, women have about half of the grip strength of men and are 4.5 inches shorter (also meaning also a shorter arm span). Thus, difficulties may arise for women related to seat adjustment and arm length needed to reach both the patient and the instrument tray. As women generally have less strength than men, a higher level of force may be needed in comparison to their male counterparts (Kroemer and Grandjean, 1997). Instruments may not be designed based on the size dimensions of the female hand, even though the majority of hygienists, assistants and hygiene/assistant students are female.

Cost of WRMSDs in dentistry

In the year 2000, there were approximately 147,000 dental hygienists and 247,000 dental assistants in the United States (BLS,2000). The Bureau of Labor and Statistics projects dental hygiene to be one of the 30 fastest growing occupations nationwide. Some 2,990 dental hygienists and 3,460 dental assistants were employed in the state of Connecticut alone according to year 2000 data. Furthermore, the Connecticut Department of Labor (DOL) named dental hygiene as one of the fastest growing occupations in the state with a 23.5% increase expected through 2010. Dental assisting was also categorized in as one of the fastest growing occupations with a 23.8% increase through 2010 (DOL, 2000).

From the figures above, it is apparent that the numbers of both hygienists and assistants will rapidly increase in the coming years. As increasing numbers of workers enter these two fields, the incidence of MSDs will likely increase, bringing with it a subsequent increase in cost.

According to a 1993 study done by Oberg *et al*, the loss of income to dental practitioners due to MSD pain (lost work days) was greater than \$41 million per year. Dental offices must also cope with increases in insurance premiums for injured employees and the cost of replacing an employee who cannot return to work (*i.e.* training and orientation of new employees). The use of ergonomic programs to reduce musculoskeletal pain is a cost-effective solution to this issue. Substantial evidence exists regarding the use of ergonomic programs and the reduction of injuries. For example, an early intervention program for low-back pain in dentists reduced claims by nearly 56% after only one year (Van Doorn, 1995). Studies have also proven the adaptability of

ergonomic principles to dental hygiene specifically, allowing dental offices to modify programs to meet their needs (Michalak-Turcotte, 2000). By providing training and education in this area, dental offices can reduce incidence of injury, lower insurance premiums and eliminate the costs associated with retraining.

Chapter 4. Ergonomics

OSHA and the Ergonomics Standard

The study of ergonomics is involved with adapting both the environment and the tools of the work setting to the individual operator and is defined as the study of humans at work in order to understand the complex interrelationships among people, their work environment, job demands and work methods.

Ergonomics has been largely ignored by occupational regulatory bodies such as OSHA (Occupational Safety and Health Administration). According to the OSHA Act, on which OSHA was founded, OSHA is required to provide that all workplaces are “place(s) of employment free of recognized hazards that are causing or likely to cause death or serious physical harm” (Cullen, 2002). A review of the current literature on musculoskeletal disorders provides convincing evidence that MSDs cause physical harm to employees. Yet, an ergonomics standard has yet to be enacted, primarily due to heavy opposition from several influential lobbyist groups including the National Association of Manufacturers (NAM) and the National Coalition on Ergonomics (NCE). Foes of the standard argue that compliance would cost billions and that “sound science” has not been used in the evaluation of MSDs (Cullen, 2002). Such critics ignore the fact that several studies have shown the cost of MSDs to be much higher than the cost of specific prevention efforts (Webster and Snook, 1994). Furthermore, NIOSH (the research arm of OSHA) in a review of over 600 studies concluded that a “*substantial body of credible epidemiologic research* (italics added) provides strong evidence of an association

exposure” (NIOSH, 1997). Oddly, many businesses that deny the need for an ergonomics standard while simultaneously incorporating ergonomics in company health and safety programs (Cullen, 2002).

The history of the fight of labor and public health for an ergonomics standard is filled with roadblocks. In both 1995 and 1996, Congress placed appropriation riders in OSHA’s budget restricting funding for work on ergonomics. In 1998, Congress set a specific restriction against OSHA's issuance of an ergonomics standard in that year. Despite such pitfalls, OSHA managed to issue a proposed standard in 1999, which was followed by immediate lawsuits on behalf of industry. In March 2001, Congress used the Congressional Review Act to overturn the enacted standard and banned OSHA from issuing any “substantially similar” standard. OSHA standard (Cullen,2002).

Although the standard was eventually overturned, many in the labor movement have continued the fight. A recent bill in CT would require an ergonomic plan for all workplaces within the present health and safety programs (CT HB 6211, 2003)

Ergonomics in dental hygiene education

The ADA is also working to exclude dentistry from any unreasonable standard on ergonomics. The legislative section of the ADA website comments that “the ADA has submitted formal comments and will testify before OSHA to ensure that the agency understands how the regulations will impact dental offices and why dentistry should be exempt until scientifically valid and dental specific information on musculoskeletal disorders is available” (ADA,2003).

Dental hygienists must be licensed by the state in which they practice. The requirements for licensure are graduation from an accredited dental school involving both a written and clinical examination. Very few studies have been done on the extent and quality of ergonomic education in dental hygiene programs. There are currently 216 accredited dental hygiene programs in the United States (and 248 accredited assistant programs); however, ergonomics education is not a requirement of accreditation for either type of program (ADA, 1998).

According to a recent study, 98% of schools provided training on proper patient/operator positioning and instrumentation techniques, yet, 83% of those programs reported students received less than 10 hours of credit in these areas (on average only 3 credits were required of 1948 total credit hours required). The top two reasons schools stated as explanations for the lack of ergonomic education were not enough time and under-educated faculty. Only 4% of schools employed persons specialized in ergonomic training. Programs offering baccalaureate degrees were significantly more likely to offer more education in ergonomics. Thus, the survey suggests that limited resource connections to dental schools and/or university settings may further prohibit learning by educators in associate degree settings (Beach and DeBiase, 1998). The possibility also exists that the lack of a recognized federal ergonomics standard contributes to the absence of quality ergonomics education in dental hygiene schools.

CT currently has three accredited dental hygiene programs (Tunxis, University of Bridgeport and University of New Haven) with a total current enrollment of 196 students (Spigel, 2001). Of these students, the average annual graduation rate for the 1997-2001 school years for all three schools combined was 102 students per year. According to the

DOL, schools will need to provide approximately 131 students per year to fill all available openings. Thus, with fewer new hygienists graduating than are needed to fill slots, those hygienists already in the field are left to work longer hours and cater to more patients, potentially increasing their risk for MSDs.

Chapter 5. The study

Methods

Cohorts

The cohorts of dental hygienists and students that will be further discussed in this paper originate from a 5-year NIOSH funded prospective cohort study examining the possible relationship between vibration and musculoskeletal disorders. Over the course of the research, this study will involve five cohorts, two of which are international in scope. However, due to the limited focus of this paper only the dental hygienists and dental hygiene students will be discussed here. Again, for analysis purposes, the student cohort was broken down into those with training-related clinical exposures alone (dental hygiene students) and those who had additionally worked or currently worked in the dental field although with current training-based education (dental assistants).

Experienced dental hygienists were selected from a mailing to 400 randomly selected licensed dental hygienists in central Connecticut. All participants must have had at least five years experience in the field and could not be retired. Dental hygiene students were orally recruited by faculty at each of the three dental hygiene schools (Tunxis, the University of New Haven and Fone) in Connecticut. After obtaining informed consent, participants were asked to complete a 40- page questionnaire, undergo an extensive upper extremity physical examination and complete a battery of diagnostic tests including surface nerve conduction, tactometry and plethysmography. Each of the aforementioned tests was used to assess possible risk factors and outcomes relating to the development of musculoskeletal disorders in this cohort.

tests was used to assess possible risk factors and outcomes relating to the development of musculoskeletal disorders in this cohort.

Questionnaire

The core section of the questionnaire was taken in part from a previous musculoskeletal study termed the Connecticut Upper Extremity Surveillance Project (CUSP) undertaken to assess the period prevalence of cumulative trauma disorders in Connecticut (Warren *et al*, 2000). Relevant questions relating to the objectives of the current study were included as well as sections from several other previously validated instruments used in MSD research (OSHA draft checklist, Job Content Questionnaire, Standardized Nordic Questionnaire). Also included was a separate section to assess vibration exposure developed from a collaboration of different questionnaires used in HAVS (Hand-Arm Vibration Syndrome) research. The full questionnaire contains questions from each of the following areas:

- A full occupational history for the previous ten working years
- A breakdown of current time usage on specific tasks relating to vibration use
- An assessment of psychosocial risk factors for MSDs (JCQ)
- Specific questions detailing the type, location and severity of symptoms of pain, paresthesia, or whiteness in hands or fingers and pain, paresthesia, limited movements, or spasm in shoulders, elbows, neck, forearms and lower back

- A detailed record of tasks done outside of work that may relate to vibration or biomechanical exposures (e.g. chainsaw use, computer use etc....)

Physical Examination

The physical examination was a 30-minute intensive upper extremity evaluation performed by a physician specifically trained in assessing musculoskeletal symptomatology. The physical had four stated purposes: elicitation of clinical signs, the assessment of neuromuscular, vascular and musculoskeletal function, the recognition of possible signs of HAVS (Hand-Arm Vibration Syndrome), and the development of differential diagnoses based on clinical findings. The complete physical was developed for the Ergocenter in the University of Connecticut Health Center Upper Extremity program and includes: examination of 32 muscle groups, assessment of functional mobility, postural integrity and possible discomfort derived from movement, 20 previously validated provocation tests and grip and pinch strength by dynamometer. Examples of possible diagnoses include: carpal tunnel syndrome (CTS), lateral or medial epicondylitis, ulnar neuritis, rotator cuff, thoracic outlet syndrome, and flexor and extensor tendonitis.

In addition to the questionnaire and physical examination, cold-challenge plethysmography, tactometry, and surface nerve conduction was performed on all participants by experienced technicians. As the data for these tests has not yet been analyzed and this paper addresses primarily neck and shoulder concerns, the methods for these tests are not described in detail here. An exposure assessment of the cohort of

hygienists in also planned for the spring of 2003, involving PATH analysis and tool simulations.

Statistics

All statistics were generated using SPSS version 10.1 for Windows. Frequency tables were generated for symptoms reports, diagnoses and biomechanical factors (crosstabs). Bivariate analysis was utilized to define zero order correlations (excluding cases pairwise). Multivariate analysis (binary logistic regression) was performed on all 29 independent variables by determining statistically significant (using $p < .10$ for inclusion in the equation) variables using forward conditional analysis. Those variables (including age in all models) were then used in an enter method binary logistic, with age included in all models. Independent samples T-test were used to compare means of certain risk factors against outcomes.

Results

Questionnaire

Ninety-four experienced (had worked for at least five years in the field) Connecticut dental hygienists and sixty-six dental hygiene students from the three accredited Connecticut dental hygiene participated in the study. For analysis purposes, the dental hygiene students were split into two groups: those that had only education based dental exposures (dental hygiene students) and those that had previously or did currently work in the dental field (dental assistants) in addition to their dental hygiene education. A total of twenty-seven dental hygiene students and thirty-nine dental assistants took part in the study.

The response rate for the hygienist mailings was 23.5% (94 subjects out of approximately 400 mailings [reduced by the number of ineligible and incorrect addresses]). Demographics for the groups are presented in Table 2. The mean age of the hygienists was 45.6 years (median of 45 years) and the mean number of years in the dental field was 21 years (median of 26 years). The assistants had a mean age of 27.9 years (median of 28 years) and had worked in the dental field for a mean of 5.0 years (median 8 years). Approximately 46% of those categorized as assistants in this cohort were both currently working and attending school, with 54% having ceased employment in the previous two years. The mean age for the students was 23.6 (median 25 years). In regards to clinical time, 33.3% of students reported less than one year of clinical time, while 12 (18.2%) reported no clinical exposure.

Of the three groups, the dental hygienists spent the most time per week in dental work with an average of 26.9 hours/week (median=26). Assistants and students spent means of 15.9 (median=12) and 6.2 (median=5) hours per week in dental work, respectively.

Approximately 98.1% of the total sample was female and 94.4% were Caucasian. 138 (86.3%) of all participants reported their right hand as dominant, while 9 (5.6%) were left-handed and 3 (1.9%) were ambidextrous.

Table 2: Demographic and work characteristics of experienced hygienists (DH), assistants (DA)* and dental hygiene students (DS).

		<i>DH</i>	<i>DA</i>	<i>DS</i>
Demographics/Workload	<i>Age (mean)</i>	45.6	27.9	23.6
	<i>Years in dental field</i>	21.0	5.0	N/A

		<i>DH</i>	<i>DA</i>	<i>DS</i>
	<i>Dental hours/week (mean)</i>	26.9	15.9	6.2
	<i>Patients treated/day</i>			
	None	0	2.8	5.6
	1-5	4.4	72.2	94.4
	6-10	65.6	16.7	0
	11-15	25.6	5.6	0
	15+	4.4	2.8	0
Tool use:	<i>Number manual hours/week (mean)</i>	12.0	5.8	4.4
	<i>Number vibration hours/week (mean)</i>	5.1	3.4	4.6
	<i>Ultrasonic scaling hours/week (mean)</i>	1.49	1.4	1.14
	<i>Sonic scaling hours/week (mean)</i>	0.30	0.10	0
	<i>Slow speed handpiece hours/week</i>	1.71	0.50	0.56
	<i>Model trimming hours/week (mean)</i>	0.22	0.30	0.22
Miscellaneous:	<i>Computer hours/week (mean)</i>	4.85	6.9	8.9

Notes: *Dental assistants are dental hygiene students who also presently or previously worked as dental assistants.

All values are means except patients/day which is a categorical variable (reported is the percentage of each cohort in each category).

Hygienists and assistants spent a relatively greater number of hours spent manual instruments while students tended to spend equal time with both types of instruments. Hygienists reported an average of 12 current manual hours/week as opposed to only 5.1 current vibration hours/week. In terms of specific vibration-related tasks (shown in Table 3), all participants were asked to provide estimates of vibratory tool usage if use of a specific set of instruments (*i.e.* ultrasonics) exceeded 1 hour/day. Hygienists reported an average of 1.49 hours/day spent doing ultrasonic scaling, 0.3 hours/day spent in sonic scaling, 1.71 hours/day spent using a slow-speed handpiece and 0.22 hours/day spent model trimming. Thus, approximately 5.6 hours/day were spent in vibration-related tasks.

Dental assistants also engaged in more manual instrument use, spending a mean of 5.8 hours in manual tasks versus 3.4 hours in vibratory tasks. Approximately 1.4 hours/day were spent in ultrasonic scaling, 0.1 hours/day in sonic scaling, 0.5 hours/day

using the slow speed handpiece and 0.3 hours/day in model trimming. A total of 2.3 hours/day were spent in vibratory tasks.

Students spent almost equal time in manual and vibratory tasks. An average of 4.4 manual hours was reported, versus 4.6 hours of vibration exposure per week. In regards to specific vibration related exposure, an average of 1.14 hours/day were spent in ultrasonic scaling, 0.56 hours/day using the slow speed handpiece and 0.22 hours/day at model trimming. A total of 1.9 hours/day were spent in vibratory tasks. No student reported using the sonic scaler more than 1 hour/day during his/her clinical training.

Table 3: Mean hours per day spent in specific vibration-related tasks by cohort

Task	Cohort		
	DH	DA	DS
<i>Ultrasonic scaling</i>	1.5	1.4	1.1
<i>Sonic scaling</i>	0.3	0.1	0.6
<i>Slow speed handpiece</i>	1.7	0.5	0
<i>Model trimming</i>	0.2	0.3	0.2

In terms of time spent in both manual and vibratory tasks, manual hand scaling combined with root planing was the most frequent activity for each cohort with approximately 80% of each cohort reporting at least one hour per day spent at this task. Hygienists also reported polishing and ultrasonic/sonic use as the second and third most prevalent activities respectively. Assistants reported heavy ultrasonic and sonic use also but more assistants than hygienists reported frequent time in tasks such as cleaning instruments and probing and exploring. Comparable to assistants, dental hygiene

students also cited probing and exploring as their most frequent activity; following manual and ultrasonic/sonic use.

Table 4: Hours per days spent in specific manual and vibration-related tasks (% each cohort reporting).

	Less than 1 hr/day			1-3 hours/day			4+ hours/day		
	DH	DA	DS	DH	DA	DS	DH	DA	DS
Manual hand scaling and rootplaning	6.6	35.3	52.4	35.2	47.1	33.3	58.2	17.6	13.3
Ultrasonic and sonic scaling	48.9	48.5	52.6	42.2	33.3	36.8	8.9	18.2	10.5
Polishing teeth	27.5	96.8	95.0	61.5	3.2	5.0	11.0	0	0
Flossing teeth	73.6	82.9	95.5	22.0	14.3	4.5	4.4	2.9	0
Writing progress notes	56.5	54.3	73.7	35.9	37.1	26.3	7.6	8.6	0
Sharpening instruments	91.0	93.9	100	7.9	6.1	0	1.1	0	0
Filing client charts	93.7	91.4	93.8	5.1	5.7	6.2	1.3	0	0
Model trimming	98.5	93.8	100	1.5	6.3	0	0	0	0
Exposing and processing radiographs	59.3	63.9	94.4	36.3	30.6	5.6	4.4	5.6	0
Cleaning instruments and treatment area	51.6	45.9	89.5	40.7	43.2	10.5	7.7	10.8	0
Exam procedures	56.5	69.4	85.7	37.0	22.2	9.5	6.5	8.3	4.8
Probing and exploring	33.3	47.1	52.4	58.9	44.1	42.9	7.8	8.8	4.8
Client scheduling	89.4	94.1	93.8	8.2	5.9	6.2	2.4	0	0

Certain subjective interpretations of specific biomechanical risk factors were also determined using the questionnaire. Participants were questioned about the percentage of time spent with neck and arms in non-neutral positions, time spent in tasks involving precision and time spent in tasks involving repetition. Responses were based on a 4- part

scale (never, seldom, often, very often). Table 5 shows the percentage of hygienists reporting either “often” or “very often” in regards to time spent in each biomechanical task. From the table, we can see that at least 60% of the hygienists believed that they were exposed “often” or “very often” to every risk factor assessed (except arms above shoulder height). In regards to tasks requiring precision and repetition, 71.0% and 80.9% of the hygienists believed they were participating in these tasks “very often”. Figure 1 (Appendix) graphs the percentage of each cohort reporting “very often” for time spent in biomechanical risk factors.

Table 5: Percentage of cohort reporting “often” or “very often” to time spent in biomechanical risk factors

Task	Often				Very Often		
	<i>DH</i>	<i>DA</i>	<i>DS</i>		<i>DH</i>	<i>DA</i>	<i>DS</i>
Neck bent	30.1	54.1	62.5		65.6	34.1	16.7
Neck twisted	51.7	33.3	12.5		25.8	5.6	0
Neck bent/twisted	39.8	38.9	12.5		32.3	8.3	4.2
Arms stretched	20.4	35.1	26.1		43.0	13.5	13.0
Arms twisted	34.4	35.1	41.7		53.8	37.8	16.7
Arms forced	38.3	43.2	29.2		23.4	18.9	12.5
Repetition	17.0	40.5	50.0		80.9	45.9	29.2
Precision	19.4	22.2	41.7		71.0	44.4	16.7
Arms above shoulder	16.0	10.8	4.2		2.1	0	4.2

Self-reports of pain, numbness and tingling, burning, spasm and whiteness of digits were also examined (Figure 2 and Table 6). Overall 87.2% of hygienists reported MSD symptoms in at least one location. Approximately 44.7% of dental hygienists reported numbness or tingling in the hands in the past 12 months. 11.7% reported blanching of the digits and 13.8% reported pain in the digits but no blanching. Specific to body regions, 73.1% reported neck symptoms, 35.1 % shoulder symptoms, 20.4 % elbow symptoms, 22.6% forearm symptoms, and 70.3% lower back symptoms. Only 37.9% had been to see their physician at least once regarding musculoskeletal symptoms in the last 12 months.

Dental assistants had fewer reports of symptoms in comparison to practicing hygienists, the notable exception being reports of whiteness. A little over half (53.8%) of assistants reported overall MSD pain. In terms of hand symptoms, about 13% noted numbness and tingling in the past 12 months, 15.4% had signs of blanching in the digits and 7.7% had hand pain. Percentages reporting neck, shoulder, elbow, forearm and lower back symptoms were 47.4%, 20.5%, 7.7%, 7.7% and 42.1%, respectively.

Dental hygiene students reported fewer symptoms than both hygienist and assistants in each area examined. Under half (44.4%) of the sample reported general MSD pain in the past 12 months. Fewer than 15% of the sample reported numbness/tingling, whiteness, hand, shoulder, elbow or forearm pain. However, 37% reported neck pain and 33% reported lower back pain, only slightly lower than assistants' reports.

Table 6: Prevalence of symptom reports for hygienists, assistants and students

Symptom	DH	95%CI	DA	95%CI	DS	95%CI
MSD pain	87.2	80-94	53.8	38-69	44.4	26-63
N/T	44.7	35-55	12.8	2-23	3.7	(-)3 –11
Whiteness	11.7	5-18	15.4	4-27	7.4	(-)2-17
Hand pain	13.8	7-21	7.7	(-)1-16	7.4	(-)2-17
Shoulder pain	35.1	25-45	20.5	8-33	11.1	(-)1-23
Neck pain	73.1	63-81	47.4	31-63	37.0	19-55
Elbow pain	20.4	12-29	7.7	(-)1-16	3.7	(-)3-11
Forearm pain	22.6	14-31	7.7	(-)1-16	11.1	(-)1-23
Low back pain	70.3	61-80	42.1	26-58	33.3	16-51

Physical

As discussed above, the physical examination assessed a variety of musculoskeletal outcomes (Figure 3 and Table 7). According to physician diagnosis, 16.0% of the hygienists presented with CTS in the dominant hand. Approximately 40.4% showed clinical signs of right trapezius pain, with 33.0% showing evident spasm in the muscle. Other common diagnoses in this group were extensor tendonitis (30.9%), flexor tendonitis (11.7%), lateral epicondylitis (10.7%), medial epicondylitis (11.7%), and ulnar neuritis (11.7%). (Note: All diagnoses are reported for right side only, assuming right as the dominant side in the majority of cases).

Similar to symptoms reports, dental assistants showed fewer clinical signs relevant to diagnosis of a specific MSD than hygienists. Approximately 8% presented with signs of CTS (about half that of the hygienists). However, more than a third of the sample experienced clinically provoked neck pain and almost one-fourth showed signs of one or more neck trigger points.

Dental hygiene students generally showed fewer clinical signs of disease than both hygienists and assistants with two notable exceptions: tendonitis and epicondylitis. The presence of extensor tendonitis in this group was significantly higher than that of the assistants and only slightly lower than the practicing hygienists.

Table 7: Prevalence of specific diagnoses for hygienists, assistants, and students

Diagnosis	DH	95%CI	DA	95% CI	DS	95% CI
CTS	16.0	9-23	7.7	(-)1-16	0	N/a
Right trapezius pain	40.4	31-50	33.3	19-48	14.8	1-28
Right trapezius TP	33.0	23-42	23.1	10-36	7.4	(-)2-17
Extensor tendonitis	30.9	22-40	0	N/a	22.2	7-38
Flexor tendonitis	11.7	5-18	0	N/a	3.7	(-)3-11
Lateral epicondylitis	10.7	4-17	2.6	-2-8	7.4	(-)2-17
Medial epicondylitis	11.7	5-18	5.1	(-)2-12	14.8	1-28
Ulnar neuritis	11.7	5-18	5.1	(-)2-12	0	N/a

Neck

Point prevalence rates for subjective neck symptoms (defined as: pain, aching, stiffness, spasm, inability to move head, burning, numbness or tingling) of 73.1%, 47.4 %, and 37.0 % were found for dental hygienists, assistants and students respectively.

Table 8: Measures of subjective neck symptoms (% in each cohort reporting)

	DH	DA	DS
Cases with no neck pain	N=26	N=21	N=17
Frequency (% of those with pain)	N=68	N=18	N=10
Constant	10.4	11.8	0
Daily	25.4	5.9	10.0
Once a week	23.9	11.8	30.0
Once a month	13.4	35.3	20.0
Every two-three months	22.4	23.5	30.0
Every six months	4.5	11.8	10.0
Duration (median years)	9.5	4.3	3
Location			
Right side	39.4	33.3	30.0
Left side	27.3	11.1	0
Middle	24.2	11.1	40.0
Both	9.1	44.4	30.0
Travel to shoulder			
No	32.4	37.5	70.0
Left only	23.5	25.0	0
Right only	8.8	12.5	10.0
Both	35.3	25.0	20.0
Travel down arms			
No	75.8	82.4	100.0
Right arm only	13.6	11.8	0
Left arm only	4.5	5.9	0
Both arms	6.1	0	0
Worst pain last 7 days (median)*	3	4	4

* Scale 1-10

Physician diagnosed neck disorders were also examined. Table 9 presents specific neck diagnoses by percentage in each cohort diagnosed.

Table 9: Specific neck diagnoses (students, assistants and hygienists)

<u>Symptom</u>	Frequency (% of each cohort)					
	DH	95% CI	DA	95% CI	DS	95% CI
Superior trapezius pain right	40.4	31-50	33.3	19-48	14.8	1-28
Superior trapezius TP right	33.0	23-42	23.1	10-36	7.4	(-)2-17
Superior trapezius pain left	37.2	27-47	28.2	14-42	14.8	1-28
Superior trapezius TP left	24.5	16-33	20.5	8-33	14.8	1-28
Scalenes right	13.8	7-21	15.4	4-27	14.8	1-28
Scalenes TP right	5.3	1-10	7.7	(-)1-16	3.7	(-)3-11
Scalenes left	13.8	7-21	10.3	1-20	18.5	4-33
Scalenes TP left	5.3	1-10	2.6	(-)2-8	3.7	(-)3-11
Neural foramen right	13.2	0-7	2.6	(-)2-8	3.7	(-)3-11
Neural foramen left	2.1	(-)1-5	5.1	(-)2-12	7.4	(-)2-17
Spurling right	2.1	(-)1-5	0	0	0	0
Spurling left	2.1	(-)1-5	2.6	(-)2-8	3.7	(-)3-11
Neck lat rotation (right)	6.4	1-11	0	0	0	0
Neck lat rotation (left)*	6.4	1-11	0	0	0	0
Neck lat flexion (right)*	9.6	4-16	0	0	0	0
Neck lat flexion (left)*	9.6	4-16	0	0	0	0
Neck flexion*	0	0	0	0	0	0
Neck extension*	1.1	(-)1-3	0	0	0	0

* Neck angles denoted % of abnormal subjects

(defined as: lat rotation <80°, lat flexion <45°, flexion <50°, extension<60°)

Tables 10 and 11 present mean values of several independent variables for each of four outcomes: no neck pain or spasm (control), subjective neck pain, objective neck pain and/or trigger point, and both subjective and objective neck pain and/or trigger point.

An asterisk denotes values significantly different from the control group as determined by independent sample T-tests. Note that students and assistants are combined here, as there were too few students in each outcome subcategory to derived significance. Figure 5 compares biomechanical means for specific risk factors (neck bent, neck twisted, neck bent and twisted and repetition) among those with, no neck pain, either subjective or objective neck pain or both subjective and objective pain.

Table 10: Dental hygienists: Neck symptom T-tests

	No neck pain (n=31)	Subjective pain only (n=15)	Objective pain only (n=7)	Subjective and objective pain (n=13)
Age	48.1	45.2	43.8	44.6
Vibration hours	3.5	5.1	1.0*	6.5*
# years in field	23.2	21.2	21.0	21.6
Hours/week	25.8	26.0	24.9	28.4
Patients/day	2.2	2.1	2.8	2.5*
Neck bent	2.4	2.6	2.3	2.8*
Neck twisted	1.8	2.0	2.0	2.2*
Neck bent and twisted	1.7	2.0	1.8	2.2*
Repetition	2.8	2.9	2.0*	2.7

Note: All reported values are means unless otherwise specified

*Statistically significant difference from control (no neck pain) ($p < .05$)

Table 11: Dental hygiene students (students and assistants) T-tests

	No neck pain (n=31)	Subjective pain only (n=15)	Objective pain only (n=7)	Subjective and objective pain (n=13)
Age	25.4	28.3	27.6	24.5
Vibration hours	3.4	3.8	2.4	1.4*
# years in field	2.6	3.9	2.6	2.0
Hours/week	7.9	3.9	4.6	9.5
Patients/day	1.3	1.1	1.0	1.3
Neck bent	1.9	2.2	2.3	2.2
Neck twisted	1.1	1.4	1.0	1.2
Neck bent and twisted	1.2	1.5	1.0	1.2
Repetition	2.0	2.3	2.6	2.1

Note: All reported values are means

*Statistically significant difference from control (no neck pain) ($p < .05$)

Correlations

The remainder of the analysis focuses on three specific neck outcomes: subjective neck pain, physician-diagnosed superior trapezius pain and physician-diagnosed superior trapezius neck trigger point. Figure 4 compares the frequency of these three outcomes in each cohort. Table 12 presents 29 risk factors experienced by dental hygienists, dental

assistants and dental hygiene students that were examined. Each variable can be placed in one of five categories: individual variables, work or task based variables, psychosocial variables, biomechanical variables and leisure variables.

Table 12: Evaluated risk factors for neck MSDs in dental hygiene

<u>Individual</u>	<u>Work/Task-based Variables</u>	<u>Biomechanical</u>	<u>Psychosocial</u>	<u>Leisure</u>
Age	Current # vibration hours	Repetition	Skill variety	Computer hours/wk
Height	Current # manual hours	Precision	Work quantity	Musical instrument hours/wk
Weight	Ultrasonic hours/day	Uncomfortable grips	Job Control	
	Dental hours/wk	Arms forced	Work intensity	
	Dental time in current position	Arms twisted	Sup support	
	# years in field	Neck twisted	Co-worker support	
	# patients/day	Neck bent		
	% patients with heavy calculus	Neck bent and twisted		
		Arms overhead		
		Arms stretched		

Table 13 present the results of logistic regression utilizing these 29 variables and the three outcome measures. Odds ratios that were significantly associated ($p < .10$) with one of three outcomes: neck pain (subjective), trapezius pain (clinically assessed) and trapezius trigger point (clinically assessed) are denoted by asterisks. Note that students and assistants are combined in the regression as sample size was not sufficient to separate the cohorts.

Table 13: Binary logistic regression of statistically significant variables and neck outcomes

	Neck pain ¹		Sup trap pain ²		Sup trap TP ²	
	DH	DA/DS	DH	DA/DS	DH	DA/DS
Height					1.11	
Weight		0.98			0.97	
Current # vib hours	1.15					0.75
Patients/day			5.78			
Repetition			0.068		0.064	
Neck bent			3.35			
Sup support	0.289					

Note: All odds ratios reported are statistically significant ($p < .05$)

¹assessed from questionnaire

²assessed from physical examination

Discussion

In the dental literature, much attention has focused on carpal tunnel syndrome as the primary concern with regards to MSDs. This study provides information that may direct attention to other important areas. Very few studies have examined dental assistants and dental hygiene students in terms of task analysis, probable risk factors for MSDs or the prevalence of subjective symptoms and physician diagnoses.

It seems clear from a review of the study results above that dental professionals at all levels suffer from a number of musculoskeletal problems and are exposed to several known risk factors for these disorders.

Several of the demographic and task differences between these cohorts are not surprising in light of the current literature. Dental hygienists are generally older, more experienced in the field, see a greater number of patients per day, work a greater number of dental hours and spend more time in specific tasks (manual and vibratory hours) and with specific tools than assistants or dental hygiene students. The hygienist cohort also reported higher levels of biomechanical demands at work (Figure 1), a greater percentage

of all subjective symptoms (Figure 2) and presented with a greater number of clinical signs (Figure 3) than both assistants and students. The overall prevalence of general MSD pain in hygienists was reported as 87%, which is in agreement with the existing literature in Connecticut (Sanders and Turcotte, 1997; Atwood and Michalak, 1992).

The prevalence rate of MSD symptoms in dental hygiene students who work as assistants was 53%, somewhat lower than has been reported previously (perhaps because half the dental hygiene assistants in this study were not currently working beyond their clinical education). Dental assistants are a little studied group, yet, the students characterized as assistants in this study were clearly distinguishable from the students with purely clinical education. Assistants reported heavier biomechanical loads (with the exception of overhead work) and increased manual tool usage as well as a greater number of dental hours overall compared to DH students. Rates of subjective symptom reports were also higher in the assistants compared to students with the exception of forearm symptoms (although none were significantly higher). In comparison, the percentage of physician reported diagnoses in the assistants was lower than that of the students in several cases (extensor and flexor tendonitis, medial and lateral epicondylitis).

Dental hygiene students assume many of the same tasks as hygienists and assistants though their total hours of dental work are fewer. Reports of manual tool usage and levels of biomechanical demands were the lowest of all three cohorts. However, dental hygiene students reported spending a greater number of hours in vibration-related tasks than assistants. Dental hygiene students also reported fewer symptoms and showed fewer clinical signs than assistants in general. There were several notable exceptions. The percentage of hand symptoms reported was roughly equivalent in students and

assistants and more students reported forearm pain than assistants. Elbow and forearm diagnoses were also elevated in students. Studies have suggested a latency period for MSDs of as much as six years due to the cumulative nature of the illness (Stentz?). However, in this study, students with as little as one year of clinical time showed evidence of increased musculoskeletal symptoms and diagnoses. This early onset of symptoms of cumulative disease may suggest a non-occupational origin, an exacerbation of previous symptoms by clinical education, or an earlier onset for this type of work. The possibility also arises that the training-related demands of the assistants do not equal that of the students (because of differences in year of education or school attended). However, it is also arguable that the mechanism of injury involving MSDs in certain locations has an accelerated rate of progression that levels off when a certain experience level is reached. Assistants with task experience may more easily modify body postures to avoid unnecessary risk. However, this would not explain the higher prevalence of certain symptoms (neck, lower back) and diagnoses/signs (CTS, neck spasm) in assistants or the elevated symptom reports and diagnoses in hygienists (who have the most experience). Regardless of the possible etiology of these trends, such findings are significant in the dental field.

Neck symptoms were the most prevalent symptoms (in regards to a specific body location) found in all three cohorts. Superior trapezius pain and spasm on exam were, respectively, the first and second most prevalent diagnoses in hygienists and assistants. Reports of neck symptoms in the hygienist cohort were considerably higher than previous studies (73.1% as compared to 43.1%) (Sanders and Turcotte, 1997; Akesson, 1999). The specific cohort of hygienists examined here was older and more experienced than

those examined previously (Akesson, 1999; Shenkar, 1998; Stentz, 1994; Anton, 2002). However, neither age nor experience was significantly correlated with any of the neck outcomes examined. In contrast, the number of patients seen per day was comparable to other studies, and showed the highest significant correlation with superior trapezius pain (previous studies have correlated patients/day with overall MSD pain, neck pain and CTS, but not specific neck diagnoses) (Ylipa, 1997; Werner, 2002). In terms of frequency and the extension of symptoms down the arms or shoulders, hygienists reported more severe pain compared to students and assistants. However, students and assistants reported slightly higher pain levels. Interestingly enough, the involvement of the non-dominant (assumed left) side of the neck in symptom reports seemed related to either age or years of experience as hygienists had the highest rates of left sided neck pain, followed by assistants, then students.

Recently, the dental field has focused on high frequency vibratory instruments as a way of reducing the amount of time spent in manual tasks that have been associated with high biomechanical loads in the hand and wrist. However, previous studies have noted an increase in “altered sensations” (defined as pain and numbness and tingling) in several body locations in related to ultrasonic use (Stentz, 1994). In this study, the current number of vibratory hours was positively significantly associated with neck pain in hygienists (OR=1.15) and negatively significantly associated to superior trapezius trigger point in students (OR=0.75). In contrast, the current number of manual hours was not significantly associated with neck outcomes in any cohort. The implications of this trend are beyond the scope of this paper. However, the possibility of heavy biomechanical as well as vibratory load, combined with the higher prevalence of

Raynaud's and carpal tunnel syndrome in women, may cause hygienists to modify work tasks and hours. Research has shown that most hygienists work no more than 24 hours per week.

In each cohort, biomechanical factors correlated significantly with both subjective and objective neck symptoms. Hygienists reported much of their time was spent in awkward postures of the neck (bent, twisted,) and with arms extended in static postures. High levels of repetition and time spent with the neck bent were significantly associated with superior trapezius pain in hygienists (odds ratios of 0.68 and 3.35, respectively). Here, repetition is seen as a protective factor that may correspond with the low levels of repetition needed for ultrasonic tools (as high levels of vibration is a risk factor). Time spent with the neck bent had the second highest odds ratio after patients per day. A recent study of a cohort of hygienists in Kentucky also found a significant positive correlation between minutes spent with the neck bent and subjective neck pain (Szeluga, 2002).

Social support was also protective against neck symptoms in students/assistants. Several authors have documented that social practices at workplaces are important factors in the development of MSDs, especially neck disorders. Close working relationships among students and faculty may be the key to decreasing psychosocial exacerbation of illnesses as well as providing quality ergonomics education. Occupations with a combination of high biomechanical loads in the neck and low social support have been documented to have a higher prevalence of neck MSDs than if any one of these factors was taken alone.

Limitations

The major limitation of this study is its cross-sectional nature as causality cannot be implied by any of the discussed associations. Few longitudinal studies have been done in these cohorts (Conrad, 1993; Barry, 1992), and the two-year follow-up planned by this study may clarify the nature of MSD development in these groups.

The possibility also exists that response and recall bias were inherent in the study design. Hygienists were randomly selected to receive mailings and student participation was voluntary as well. Those with existing symptoms may have been more likely to agree to participate and more likely to remember work practices that they believe may contribute to these disorders. Approximately 27 % of hygienists in the study reported previously diagnosed CTS.

In an attempt to filter out those students with experience in the dental field, the author created two separate exposure categories: assistants with both training-related and field experience, and students with only training-related experience. By separating these groups in analysis, the total sample of 66 students was broken down into 39 assistants and 27 students. Small sample sizes may have affected the ability to derive significance from associations of exposure and outcome.

Attempts to recognize biomechanical load levels and associate these levels with MSD outcomes were hindered by the categorical nature of the biomechanical variable. Hygienists were not asked to approximate the time spent in each demand and load levels were based entirely on self-report (no objective validation was used).

Estimating the prevalence of neck disorders is also difficult for several reasons. As discussed above, few studies focus on the neck, preferring to include the shoulder or

even the entire upper extremity. Secondly, studies that focus specifically on neck pain may have varying definitions of subjective or objective pain and make a distinction between subjective and objective symptoms. Certain studies assessing subjective neck symptoms only define pain as an outcome, while others include any combination of spasm, numbness, burning, stiffness, or aching. As this study assessed symptoms other than pain (burning, numbness, tingling, spasm), comparisons to studies examining only pain may not be valid. More emphasis is placed on objective diagnoses as the symptoms are validated by an independent observer as well as reported by the patient. However, objective studies are limited by conflicting case definitions and the quality of inter-rater reliability. Katz and Buchbinder found that little information was available as to the inter-rater reliability of neck symptoms such as muscle hardening and tenderness and limited neck movement. A later study found kappa statistics ranging from 0.4 to 0.6 (fair to good) depending on the specific clinical presentation (Ranney?). Several different physicians (all trained in occupational medicine) were utilized in this study, and rates of diagnosis may have varied by physician. However, physicians were blinded to both the results of questionnaire and further objective testing which decreases the possibility for bias.

As with any study, the chance of random statistical associations at a level of 5% is noted.

Chapter 6. Conclusions

As the study above was cross-sectional, and thus, causality cannot be implied from associations, the discussion of specific interventions may be premature. However, prospective studies have also discussed the contribution of several risk factors mentioned here such as the impact of patient load on the development of MSDs in hygienists. Several interventions strategies have been examined in the context of these risk factors and a discussion of these strategies may be valid for future preventative efforts.

Interventions

The numbers of possible interventions available in dental hygiene possibly outnumber the symptoms they are designed to prevent. The challenge is finding the interventions that work best for office, worker and patient. Dental offices that function efficiently require healthy hygienists and satisfied patients. Hygienists, in turn, are influenced by patient discomfort and office practices (scheduling, breaks, supervisor and coworker support) and, furthermore, influence patient comfort by their attitudes and practices. In order to maintain the highest level of satisfaction and health of the dental employee, dental employers, hygienists and patients must work together. Interventions may come in the form of workplace modifications, worker, or patient modifications. The interventions discussed here are focused primarily upon preventing or lessening the severity of neck MSDs, though many are applicable to other areas.

Workplace modifications

Until the mid-1960's, dental professionals delivered patient care in a standing position. Standing allowed the dental care worker to visualize the patient's oral cavity and adjust easily to accommodate both client and worker. However, excessive standing led to increased energy expenditure and increased static muscle activity and strain in the legs. To reduce increase stability and decrease energy use, dental professionals began to use the seated position. However, with this change, visual acuity decreased, forcing the dental worker to compromise neutral posture to manipulate the patient's oral cavity (Khalil, 1974).

Magnification has been used in dentistry since 1876, when dentists followed the lead of surgeons, using magnifying devices to improve precision on small work areas. Since this time, magnification has increasingly been utilized by dental hygienists and assistants and is now frequently taught in dental hygiene education (Beach and Debiase, 1998).

There are numerous benefits to using magnification devices in dentistry. As the their acuity level improves, hygienists are better able to evaluate hard and soft tissue and detect calculus and periodontal pockets and treat these conditions more comprehensively. Magnification also reduces the time spent in awkward postures, as the hygienists need not continually adjust to visualize their work area. This technique may also decrease the amount of time spent in instrumentation as hygienists can clearly see the debris needing to be removed. Older hygienists, as those that participated in this study, have a greater chance of diminished eye quality, and thus, may benefit the most from this type of intervention (Syme, 1997).

There are several different types of magnification devices. The most commonly used are through the lens (TLL) and flip-up magnification. The choice of magnification devices depends on many factors such as working distance, width of field, depth of field, angles involved and cost. The final decision to use such devices may lie with the dentist(s) of the office, as financial considerations must be taken into account. However, the use of magnification is cost-effective, costing as little as \$32 per year over a 25 year career. In comparison, ergonomic-related injuries are significantly more costly (Syme, 1997).

All instruments should promote proper ergonomic postures (neutral position) and should be well maintained to avoid use of excessive force in scaling. A mixture of manual and vibrating instruments is key; however, neither type of instrument should be used too long without a break. Tools also need to be light and of larger diameter to reduce the level of force needed to control precision, a diameter of about 1.2 cm is suggested with a range between 0.8 and 1.6 centimeters (Hortsman, 1997). Instruments used for pushing or pulling procedures should have a moderate ripple texture and those used for twisting and rotating should have longitudinal grooves to prevent slippage. Instruments and other objects should be within easy reach of the hygienist to avoid extended reaches.

Modifications to the work environment, such as armrests and adjustable seating, have also been proposed as preventative tactics. A case study by Oberg *et al* (1993) showed decreased shoulder myalgia in a dental hygienist using a horseshoe-shaped armrest. A study in a Scandinavian workplace also found that armrests helped reduce static load in the operator's arms and shoulders (Liskiewicz, 1997). Both the patient and the hygienist's chair should be automatically adjustable (height, tilt) to allow for the

comfort of both parties. The hygienist's chair should provide good lumbar support to allow for proper alignment (Davies and Eccles, 1978).

Issues of work organization can also be modified to help the dental professional better cope with or avoid MSDs. A significant positive correlation ($OR=5.78$) was seen between the number of patients seen per day and superior trapezius pain in hygienists. Hygienist control of patient scheduling may alleviate some of this burden. Dental assistants may also benefit from being involved in decision making at the office level. Frequent breaks should also be incorporated between patients to prevent high levels of muscle fatigue. However, the length of such breaks has been a matter of some controversy, as studies have shown high muscle activity by EMG even two hours after stopping dynamic work (Oberg *et al*, 1995).

Worker modifications

Neutral posture is implicit in ergonomically correct positioning. In this study, dental hygienists, assistants and students reported high levels of static and awkward postures such as neck flexion and arm extension. Several posture-based techniques, such as the Biocentric Instrumentation Technique and PAAR (placement, angulation, adaptation and removal), have been discussed in the dental literature and can provide the dental worker with individually based assessments of postures (Bramson, 1998; Branson, 2002). Clinicians should evaluate the level of comfort after using various operator positions to permit maximum control: postural weight distribution, balanced reference posture, standing and sitting positions to increase operator visibility and accessibility to the patient (Liskiewicz *et al*, 1997). Stretching exercises should also be built into postural

techniques. Stretching has been shown to improve blood flow after extended static activity and 3-5 minutes of stretching following each client is recommended (Sanders and Turcotte, 1997). Hygienists should stretch in the opposing direction of habitual positions in dental hygiene (*i.e.* neck extension stretching to oppose excess time spent in neck flexion).

Individual measures such as height and weight were also significantly correlated to neck outcomes in these cohorts (weight was protective against subjective neck pain in students/assistants and trigger point in hygienists height was a risk factor for trigger point in hygienists). Modifications of height are, of course, impossible (forgoing shoe lifts), however, adjustment of the work environment to the height of the worker may alleviate some of this risk (see seat and instrument tray positioning in workplace modifications). Previous studies have also found weight to be correlated with CTS (Akesson *et al*, 1997), however, with this disease weight is generally discussed as a risk factor. Most studies on neck pain do not examine weight as an issue. However, any employee can benefit from education in weight management. Exercise training and information may be combined with ergonomic education to increase knowledge about the impact of a sedentary life on musculoskeletal outcomes.

Continuing education is an important component of ergonomic prevention in dental work. Annual retraining for dental hygienists in blood borne pathogens is required for continued licensure and authors have suggested combining ergonomics education with such sessions (Sanders/Turcotte). Seminars, trade shows, and journal publications can also target this population. Researchers Scoggins and Cambell reported increased knowledge and increased risk factor avoidance (self-reported) after a carpal tunnel

education program. However, two-week retention ability was also found, stressing the need for continued re-education (1995).

Dental hygiene students can also benefit from exposure to education activities generally reserved for hygienists. As few dental hygiene schools provide greater than 3 credit hours of ergonomic education, supplemental training is needed. Ergonomic education should not be put off until the student is employed, as this study has shown the risk of MSDs to be significant during clinical education. Students reported almost nine hours/week spent in computer use versus only five hours/week in hygienists. Specific modifications designed for computer workers, such as ergonomically correct keyboards and adjustable computer tables, may be helpful in preventing these types of exposures.

Patient Modifications

Dental patients can also play a role in helping prevent MSDs in dental personnel. Hygienists and assistants often provide patient education to reduce the number of plaque deposits and keep gums healthy. Following such recommendations can reduce the amount of calculus present, and thus, the amount of force needed for manual scaling or the amount of time spent in ultrasonic scaling (which is used more for heavy calculus patients). Arriving early for dental appointments can also contribute to effective scheduling of the dental employee's workday.

Future research

A review of the current study results indicates a significant contribution of biomechanical factors in neck outcomes. Previous studies have developed postural evaluations of dental activities that may be useful in self-assessment. Defining and testing certain minimum postural standards may allow professional associations to establish practice standards, dental hygiene schools to develop ergonomic accreditation guidelines, and dental offices to specify operatory layout designs and equipment integration guidelines for manufacturers (Rucker et al, 2002). In light of these findings, the author plans future research in postural analysis at specific dental offices. The use of PATH (Posture, Tools, Activities, Handling) and computerized ergonomic analysis of videotapes will be used to validate subjective interpretations of biomechanical risk factors and examine patterns in posture and neck symptoms. One treatment session per hygienist will be videotaped in the late afternoon as recommended by the previous literature in this area (Sanders and Turcotte). If sample size is sufficient, comparisons will be made among cases and controls in regards to biomechanical load. Such a study will also obtain objective measures of biomechanical demands, enabling validation of self-reports in hygienists.

APPENDIX

Figure 1: Percentage reporting very often to biomechanical risk factors by cohort

Figure 2: Percentage reporting symptoms by cohort

Figure 3: Physician diagnoses by cohort

Figure 4: Comparison of three specific neck outcomes among cohorts (neck pain [both subjective and objective] and spasm)

Figure 5: Biomechanical factors in specific neck disorders (subjective and objective)

Figure 1: Percentage reporting "very often" to biomechanical risk factors by cohort

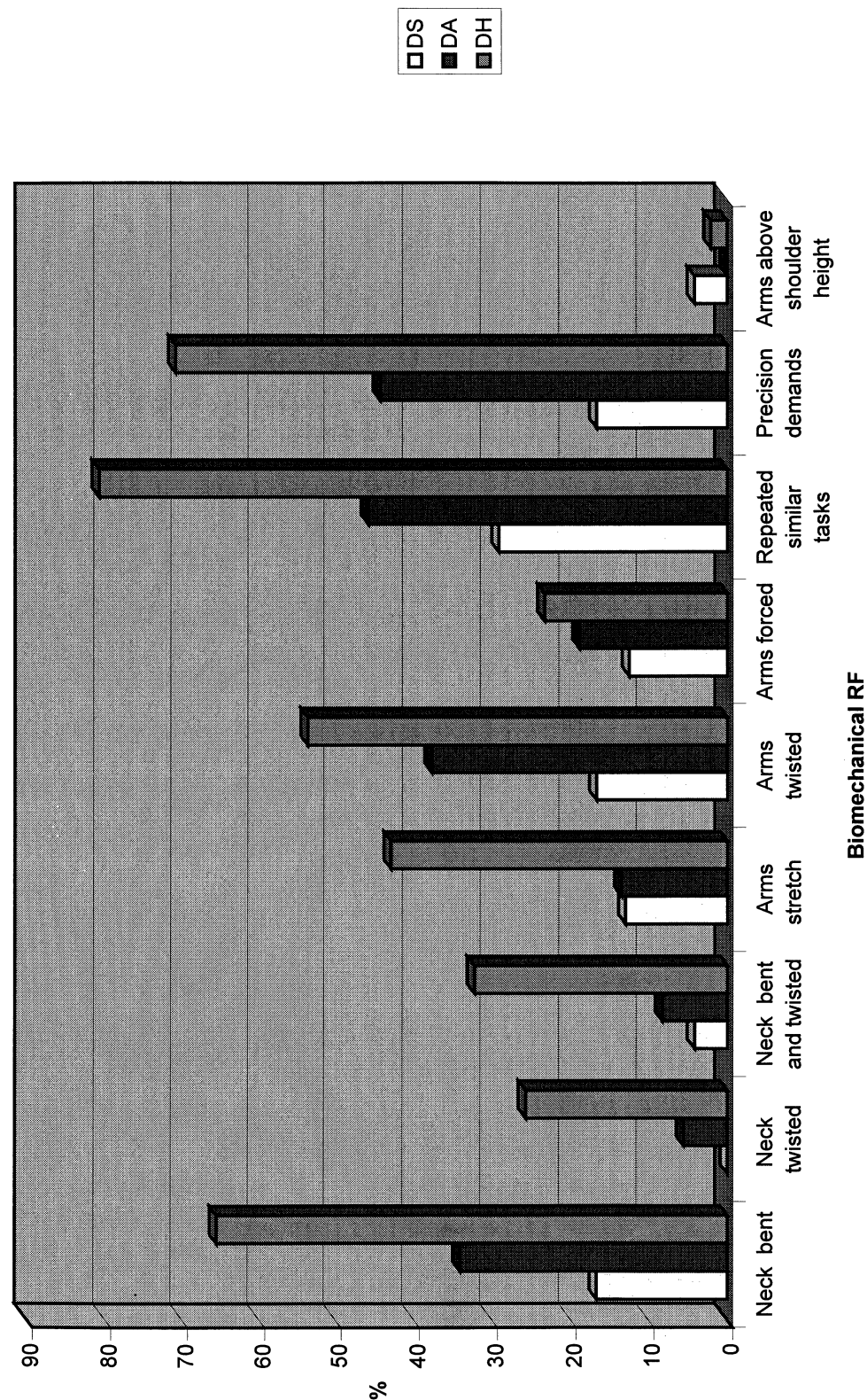


Figure 2: Percentage reporting symptoms by cohort

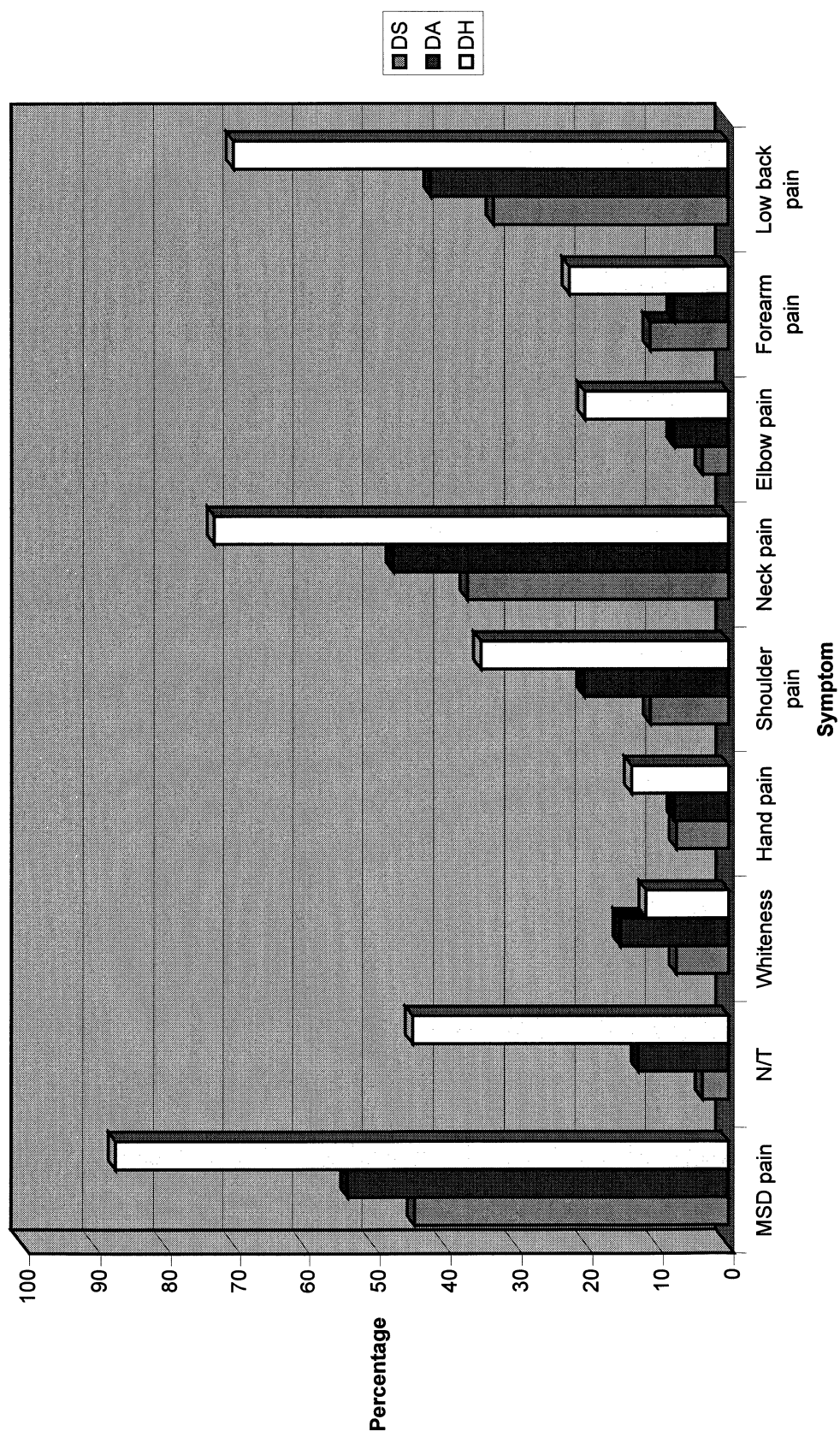


Figure 3: Physician diagnoses by cohort

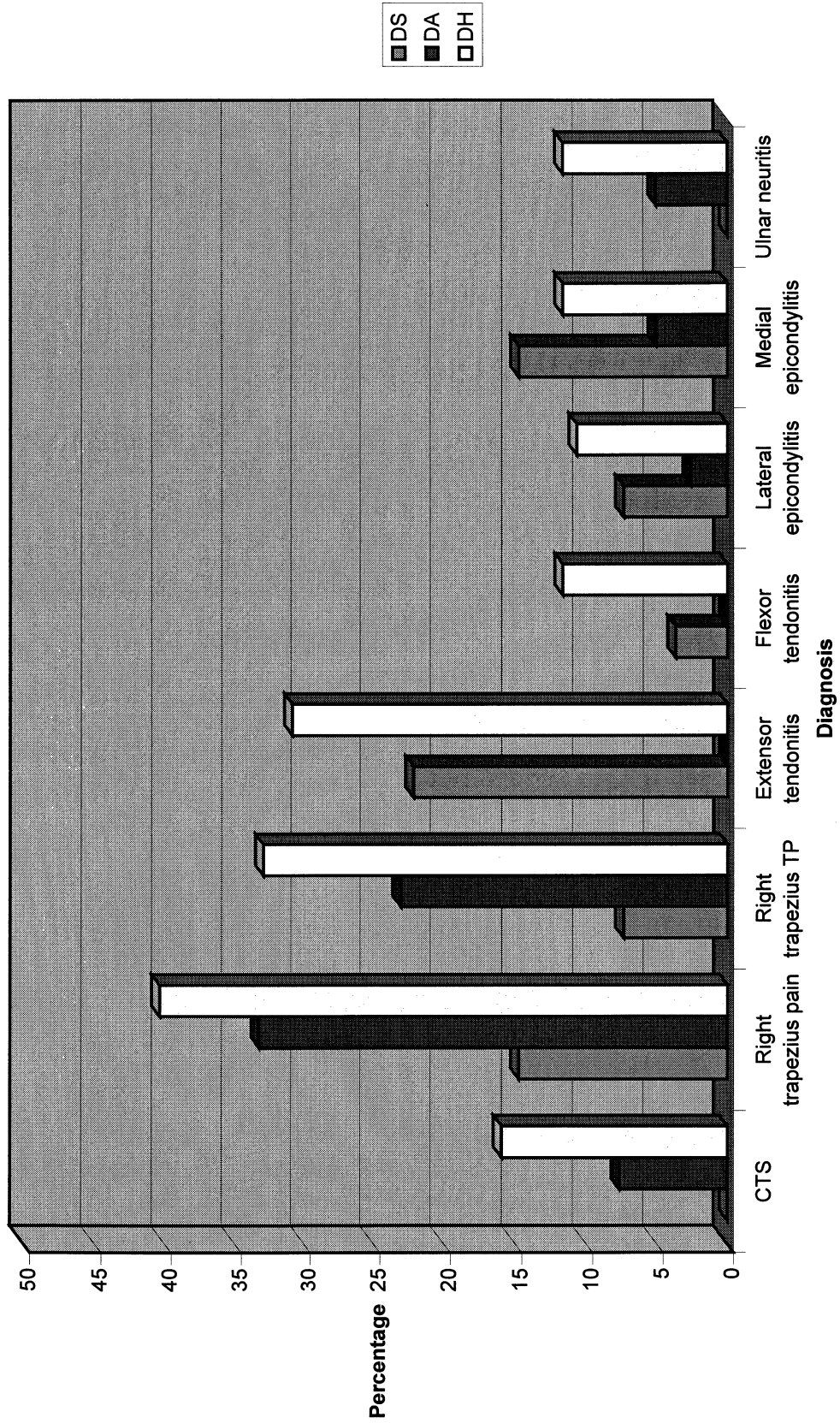


Figure 4: Specific neck diagnoses by cohort

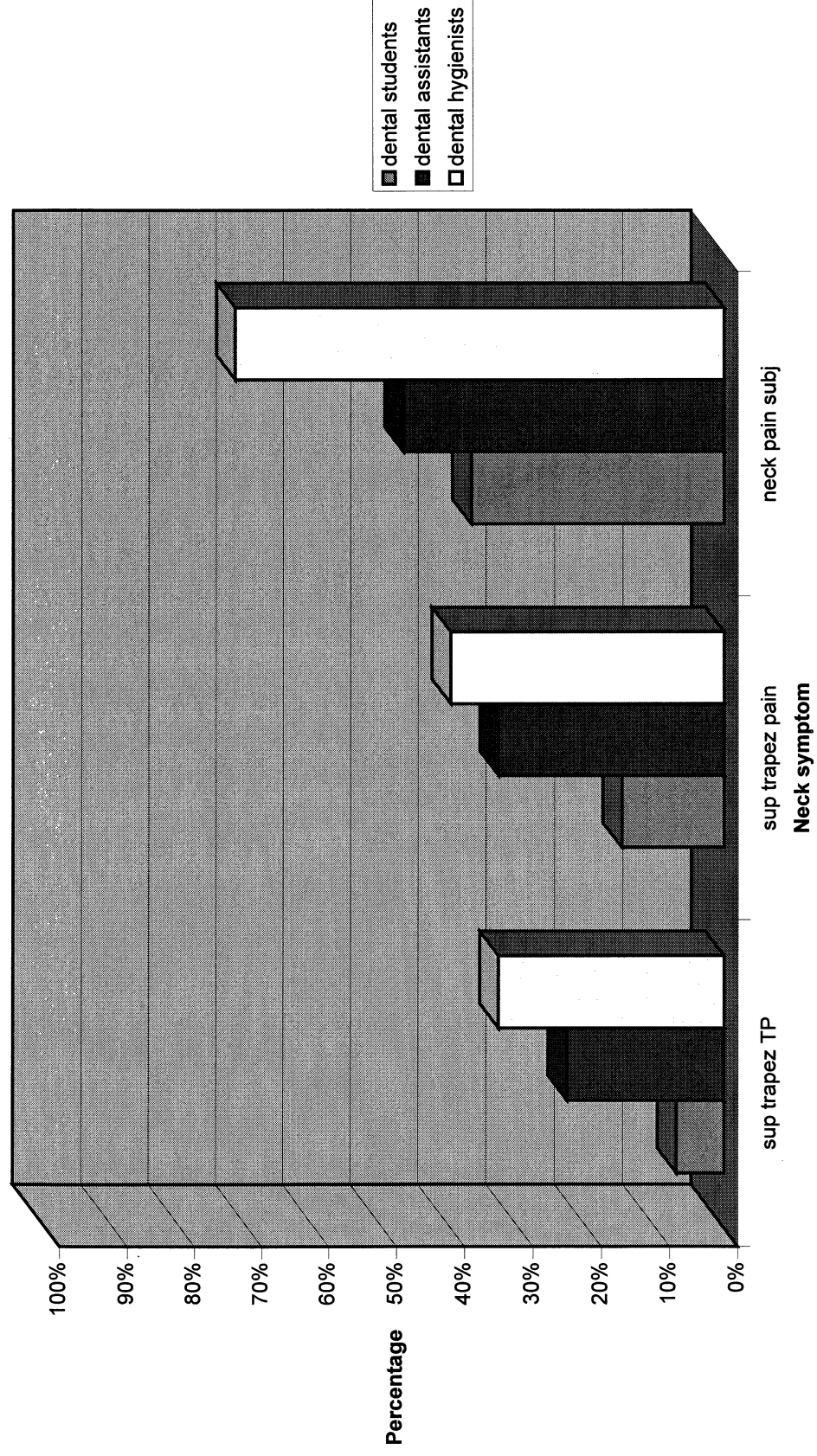
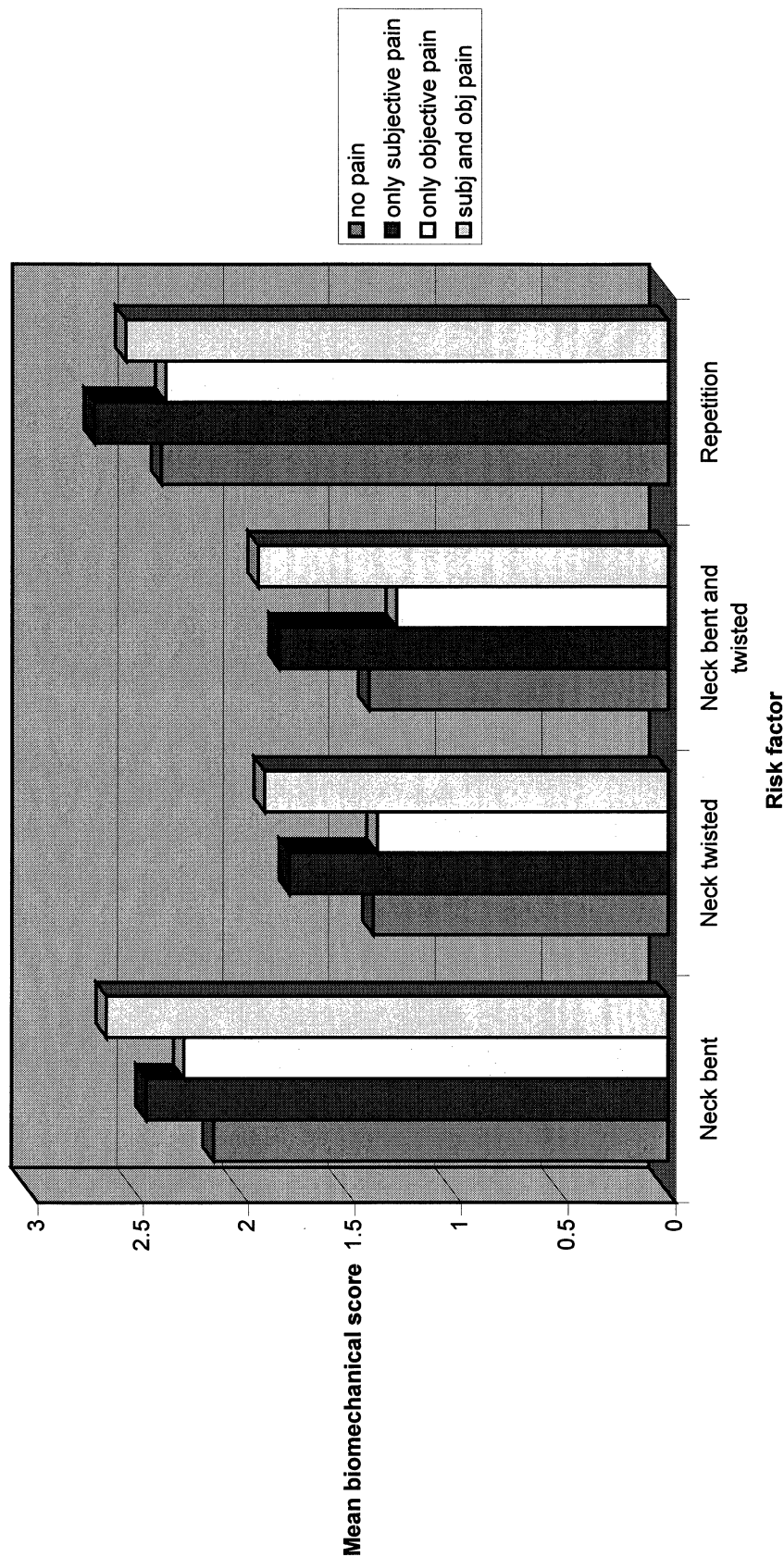


Figure 5: Neck pain and biomechanical risk factors (all three cohorts combined)



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